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SURGICAL INTERVENTIONS IN TREATMENT OF TRAUMATIC SHOULDER INSTABILITY: EFFECTIVENESS AND TRENDS IN FINLAND

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DOCTORAL DISSERTATION

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We live in a Newtonian world of Einsteinian physics

ruled by Frankenstein logic.

-David Russel

To Eeva and Ebba

ABSTRACT

In the natural course of shoulder instability, about half of the patients never experience a subsequent incident after the primary one, but also chronically unstable shoulders may eventually stabilize. The risk for recurrent episodes after primary dislocation is high among young and athletic men, and therefore, prompt surgery is often proposed for this group. Also, in treatment of chronic post-traumatic instability, surgery is often suggested. A significant increase in the total incidence and proportion of arthroscopic surgery has been widely reported during the last two decades. After a shoulder dislocation or a surgical intervention to prevent subsequent shoulder instability, mild glenohumeral osteoarthritis (OA) will likely develop within years with a minimal impact on the patient’s shoulder function.

Network meta-analyses (NMAs) have not been previously published on traumatic shoulder instability. Shoulder capsular surgery incidence rates have not been studied in Finland. Glenohumeral OA has previously been studied in the long run with non-anatomic or mixed surgical interventions with no special attention directed to arthroscopic anatomic fixation methods.

This thesis aimed to evaluate the best available evidence in treatment of traumatic shoulder instability, trends in shoulder capsular surgery procedure incidences in Finland, and long-term prevalence of glenohumeral OA and

shoulder function after arthroscopic labrum repair (LR) with bioabsorbable tacks.

We performed a systematic review and an NMA to evaluate the effectiveness of different treatment modalities after a first-time traumatic shoulder dislocation and in treatment of chronic post-traumatic shoulder instability. We examined how shoulder capsular surgery procedures were distributed in Finland during 1999-2008 between open and arthroscopic procedures geographically, between different age groups, and between publicly and privately funded hospitals after a change in the reimbursement system of occupational and traffic insurance in 2005. We retrospectively analysed a group of patients after arthroscopic LR with bioabsorbable tacks in terms of radiological glenohumeral OA and condition-specific shoulder function.

According to a moderate level of evidence, surgical treatment of primary traumatic shoulder dislocation seems to lead to fewer redislocations than non-surgical management, and according to a low level of evidence open LR prevents redislocations more efficiently than arthroscopic LR in treatment of chronic post-traumatic shoulder instability. The total incidence of shoulder capsular surgery procedures and the proportion of arthroscopic procedures increased significantly in Finland in the cohorts followed between 1999 and 2008 with notable geographical variation. Since 2005, the procedure incidences have slightly decreased in publicly funded hospitals, but have continued to increase in privately funded hospitals without a distinct change in trend. We commonly observed mild glenohumeral OA among patients treated with arthroscopic LR with bioabsorbable tacks, but its impact on shoulder function was minor.

LR reduced efficiently recurrent shoulder dislocations after primary traumatic shoulder dislocation, but routine surgical intervention can still be considered over-treatment in the typical patient population. In Finland, total incidence of shoulder capsular surgery procedures, proportion of arthroscopic procedures, geographical variation in procedures, and proportion of older patients increased significantly, which might indicate differences in regional treatment practices or background incidence. The insurance companies may have referred patients to private hospitals for better availability of treating surgeons, faster access to treatment, and lower total expenses. In the long run, mild radiological glenohumeral OA was commonly observed, but the surgical method itself is probably not significant in the development of glenohumeral OA. The impact of glenohumeral OA on the patient’s shoulder function was minor, with few objective findings.

CONTENTS

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following original articles, which are referred to in the text by their Roman numerals:

I. Kavaja L, Lähdeoja T, Malmivaara A, Paavola M. Treatment after traumatic shoulder dislocation: a systematic review with a network meta-analysis. Br J Sports Med 2018;52:1498-1506

II. Kavaja L, Malmivaara A, Lähdeoja T, Remes V, Sund R, Paavola M. Shoulder Capsular Surgery In Finland Between 1999 And 2008: A Nationwide Register Analysis. Scand J Surg. 2018;107(2):172-179

III. Kavaja L, Malmivaara A, Lähdeoja T, Remes V, Sund R, Paavola M. Effect of change in financial reimbursement on shoulder capsular surgery in Finland between 1999 and 2008: a nationwide register analysis. Submitted

IV. Kavaja L, Pajarinen J, Sinisaari I, Savolainen V, Björkenheim JM, Haapamäki V, Paavola M. Arthrosis of glenohumeral joint after arthroscopic Bankart repair: a long-term follow-up of 13 years. J Shoulder Elbow Surg. 2012;21(3):350-355

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ABBREVIATIONS

AL	Arthroscopic lavage
CI	Confidence interval
COI	Conflict of interest
ER	External rotation
IR	Internal rotation
LR	Labrum repair
MA	Meta-analysis
NMA	Network meta-analysis
NSM	Non-surgical management
OA	Osteoarthritis
QoL	Quality of life
RC	Rotator cuff
RCT	Randomized controlled trial
ROM	Range of motion
RR	Relative Risk
SD	Standard deviation
SR	Systematic review
WOOS	Western Ontario Osteoarthritis of the Shoulder
WOSI	Western Ontario Shoulder Instability Index

1 INTRODUCTION

The shoulder is the most commonly dislocated large joint (1). The direction of the dislocation is usually anterior and the dislocation is regularly of traumatic origin (2, 3), but also quite commonly related to sports (4). A shoulder dislocation results in structural damage (i.e. labral lesion) almost without exception (5). However, pathognomonic clinical presentation of an essential lesion of shoulder instability is avulsion of the anterior capsulolabral complex inferior to the equator of the glenoid (6). Additionally, bony structures may be injured (e.g. the humeral head or the glenoid either alone or together), which potentially contribute to recurrent dislocations (7). The overall incidence of shoulder dislocations in the general population has been reported to be between 12.3 (8) and 56.3 (9) or in men under 20 years of age even as high as 98.3 per 100,000 person-years (10). A shoulder dislocation and possibly consequent chronic shoulder instability is a significant and costly health issue (11).

The most significant identified risk factors for a primary shoulder dislocation and subsequent recurrent instability episodes are male sex and patient age of under 30 years. Other risk factors for recurrent shoulder dislocations include the presence of bony lesions, mechanism of injury, reduction method, and post-reduction shoulder immobilization type or time, although the evidence for these has not reached statistical significance (11, 12).

After a successful reduction of the dislocated shoulder, the goal of treatment is to restore a functional, painless, and stable shoulder with a maximum range of motion (ROM) (13, 14). Usually immobilization in a sling or a collar and cuff with shoulder in adduction and internal rotation (IR) has been suggested (13, 15, 16), and immobilization of the injured upper extremity in external rotation (ER) has not proven to be superior in reducing subsequent recurrent instability episodes (17-20). The clinical presentation of shoulder instability has a great variation after the primary shoulder dislocation from asymptomatic to symptoms interfering with normal daily activities (21). A recurrent event may never happen, but a constant feeling of apprehension and weakness or pain in the shoulder may decrease the patient's quality of life (QoL) (22). At the other end of the spectrum, the patient may suffer recurrent dislocations, but consider them only a nuisance (13).

There is evidence that only about half of the patients suffer a recurrent shoulder dislocation after the primary one, and it is also plausible that chronically unstable shoulders may stabilize over time (23). In rehabilitation of shoulder instability, muscle strengthening is of the utmost importance (24). If recurrent instability persists after a devoted structural rehabilitation programme (25), surgery can be considered (16). After a first-time shoulder dislocation, the management varies considerably by country and clinician (26, 27). Also, surgical stabilization with widely varying methods in patients with chronic post-traumatic shoulder instability is often suggested (26-29). A few direct meta-analyses (MAs) with mixed quality of the studies included have been previously published (14, 30, 31), but all different treatment modalities are not evaluated in detail in a network meta-analysis (NMA).

Due to the advancement and popularity of arthroscopic surgery, if surgery is required, an arthroscopic repair after a first-time traumatic shoulder dislocation and in treatment of chronic post-traumatic shoulder instability is performed as a primary procedure to prevent recurrent shoulder instability (32). The incidence of all shoulder capsular surgery procedures has increased markedly in the published literature, and the proportion of arthroscopic surgery has rapidly increased, constituting up to 92% of all shoulder capsular surgery procedures at the beginning of the 21st century. Published register data are nationally narrow or consist of only a few year-cohorts (33-40). It is not known whether the true population-based incidence of shoulder dislocations has increased to justify the increased surgery rates, but in general multifactorial root causes have been speculated (38, 41, 42). In Finland, employers are obligated to take out privately administered statutory workers' compensation insurance to cover their employees against occupational injuries and diseases. Previously, the private insurance companies paid an estimated tax to public health care to cover the treatment expenses of the insured patients. Since 1.1.2005 the pre-estimated tax was no longer paid, and the insurance companies started to pay for the actual treatment, and therefore, were also entitled to direct the patients to a self-chosen service provider in order to minimize delays in patients' care and rehabilitation. It is not known if or how the change in the reimbursement system has impacted on shoulder capsular surgery rates in publicly and privately funded hospitals.

Traditionally, patient outcomes have been evaluated objectively with radiographs, ROM, strength, and pain (43, 44), but interpretation of their relevance is highly subjective (43), and these outcomes indicate poorly the functional and psychological aspects of health (44). Shoulder dislocation may have short- and long-term implications for patients, even increasing mortality rates (45). Nevertheless, the impact of shoulder instability on patients' QoL and shoulder function is poorly known (22, 46-52).

In the long run, primary glenohumeral osteoarthritis (OA) has been considered somewhat rare (53). However, OA may develop on a dislocated shoulder within several years, and risk factors for the condition are as follows: patient's age over 25 years at the time of first shoulder dislocation, high-energy mechanism of injury, and alcohol abuse (54). In a follow-up study, repeated dislocations prior to surgery significantly increased the prevalence of post-traumatic OA (55). According to the published literature, the role of surgery is probably not relevant to the prevalence or severity of glenohumeral OA, but the analysed surgical procedures have for the most part been non-anatomic repairs (54, 56). Post-traumatic glenohumeral OA is most commonly classified as mild (54-57), and the impact on patients' satisfaction with overall condition and shoulder function is reported to be minimal (55, 56).

The purpose of this thesis was to evaluate the effectiveness of current treatments for traumatic shoulder instability. We present the first nationwide register analysis of the trends and distribution of shoulder capsular surgery procedures in Finland. We also present the long-term prevalence of glenohumeral OA and shoulder function after arthroscopic labrum repair (LR) with bioabsorbable tacks.

2 REVIEW OF THE LITERATURE

2.1 SURGICAL ANATOMY AND STABILITY OF THE SHOULDER

The bony shoulder comprises the proximal humerus, scapula, and clavicle. The shoulder is traditionally considered as the glenohumeral joint; however, the shoulder consists of three additional articulations (the acromioclavicular joint, the sternoclavicular joint, and the scapulothoracic joint), which grant the shoulder additional stability and ROM (58, 59). The proximal part of the humerus articulates with the significantly smaller, shallow, and usually concave glenoid cavity at the lateral side of scapula to form the glenohumeral joint (60). The glenoid is usually shaped as an inverted comma, concave, and slightly retroverted (60-62). Due to the size mismatch between the glenoid and the humeral head, a maximum of 30% of the articular surface of the humeral head articulates with the glenoid at any time during motion (62, 63). The size divergence also predisposes the glenohumeral joint to poor bony stability, which makes the stability highly dependable of soft tissues working as cooperative stabilizers (60, 62, 63). On the other hand, in the absence of restricting bony structures the shoulder has the highest ROM of the human body (62).

The glenohumeral joint capsule expands from the glenoid to the anatomical neck of the humerus (60). The joint capsule is covered with muscles of the rotator cuff (RC) (64), and all RC muscles originate from the scapula and the tendons attach to the humeral head in a horseshoe-like pattern (58, 65). The glenohumeral joint capsule has three thick segments, which are called the glenohumeral ligaments (GHLs). The ligaments are named according to the anatomic position as superior (SGHL), middle (MGHL), and inferior (IGHL) (58, 61, 66, 67). The axillary pouch is localized between the anterior and posterior IGHL bands and has been described to resemble a hammock in which the humeral head lies (60, 62, 68-70).

The glenoid fossa is surrounded by a labrum (71), which conjoins superiorly with the long head of the biceps tendon (LHBT) and provides an attachment site for the joint capsule, MGHL, and IGHL (61, 62, 66, 68). The normal glenoid labrum and three anatomic variants are presented in Figures 1A-D. The sublabral sulcus (Figure 1B) is more common in elderly patients and describes a recess adjacent to the LHBT insertion site around the cranial glenoid rim at the medial side of the labrum. The sublabral hole (Figure 1C) is an anatomic detachment of the labrum and is located typically slightly more anteriorly from the attachment site of the LHBT. The sublabral hole is present in 11% of patients, but may also coexist and communicate with the superior sublabral recess. The Buford complex (Figure 1D) is present in 1.5-2% of patients. As a variant, the MGHL is considerably thickened and attaches directly to the anterosuperior glenoid, and the anterosuperior labrum is absent (58, 61, 66, 67). All three anatomic variations may be misdiagnosed as a detached anterosuperior labrum (58).

Figure 1. Schematic illustration of the normal capsulolabral complex and anatomical variations, which are shown on a lateral view onto the glenoid. (A) Normal anatomy; (B) Sublabral recess (sublabral sulcus); (C) Sublabral foramen (sublabral hole); (D) Buford complex. LHBT: Long head of biceps tendon; SGHL: Superior glenohumeral ligament; MGHL: Middle glenohumeral ligament; IGHL: Inferior glenohumeral ligament. Reproduced with permission from Redouane Kadi. Kadi et al. Journal of Belgian Society of Radiology 2017 (72).

The anatomic structures of the shoulder maintain stability in a complex combination divided into static and dynamic stabilizers (73). The glenohumeral joint capsule is anatomically lax, restricting the wide ROM and stabilizing the joint only when the shoulder approaches the limit of normal ROM and stability (60, 62). The glenohumeral ligaments tighten when ROM and stability approach normal limits and apply a compression force on the humeral head against the glenoid, stabilizing the joint (60, 74). The labrum improves stability in the glenohumeral joint by increasing the glenoid socket depth by 50% (75), enhances congruity, creates a suction effect, and functions as an anti-shear bumper during shoulder motion (60, 62). A negative pressure inside the glenohumeral joint capsule brings relative stability with the suction effect of the labrum to the glenohumeral joint (60, 76). The RC muscles assist in control of shoulder movement and play a relevant role in creating the concavity-compression to support the glenohumeral stability (62). Through the compression mechanism, the muscular contraction compresses and centralizes the humeral head to the glenoid and increases the required force to translate the humeral head (73, 77, 78).

Proprioception is essential for joint stability and motor control. Mechanoreceptors in muscles, tendons, and joint capsule ligaments provide proprioceptive information to the static and dynamic stabilizers of the shoulder (79), which evoke the essential neuromuscular control to maintain shoulder stability and movement patterns (78, 80).

2.2 SHOULDER INSTABILITY

2.2.1 PATHOANATOMY AND PATHOPHYSIOLOGY

Anterior dislocation predisposes the shoulder to various intra-articular and extra-articular structural damage (6, 21). During an acute anterior dislocation the humeral head is displaced from the glenoid socket, which most typically results in a lesion of the anterior labrum – the Bankart lesion (Figure 2A) (81). Even though the lesion has been named after Bankart, it was originally introduced by Perthes in 1906 (82). The anterior labral detachment was historically described as the essential lesion of traumatic shoulder instability (81). Nowadays, the essential lesion is defined more specifically as a Bankart lesion with avulsion of the anterior capsulolabral complex inferior to the equator of the glenoid (6). The lesion of the capsuloligamentous complex has been described to be present almost without exception in patients with traumatic shoulder instability (5), and the role of an isolated labrum lesion in development of recurrent instability has been questioned (83).

Other damage to the soft tissues may also occur, e.g. Perthes' lesion (Figure 2C) and anterior labral periosteal sleeve avulsion (ALPSA) (Figure 2D) are close variants of the Bankart lesion (84). In Perthes' lesion, the anteroinferior labrum is incompletely detached from the glenoid, while the periosteum remains intact, but is retracted medially (85). By contrast, in ALPSA, the periosteum is intact, but the anteroinferior labroligamentous structures are retracted medially (84). Glenolabral articular disruption (GLAD) (Figure 2E) is a concomitant traumatic cartilage lesion (86), whereas humeral avulsion of glenohumeral ligaments (HAGL) (Figure 2F) is generally an avulsion of anterior IGHL from the humeral neck.

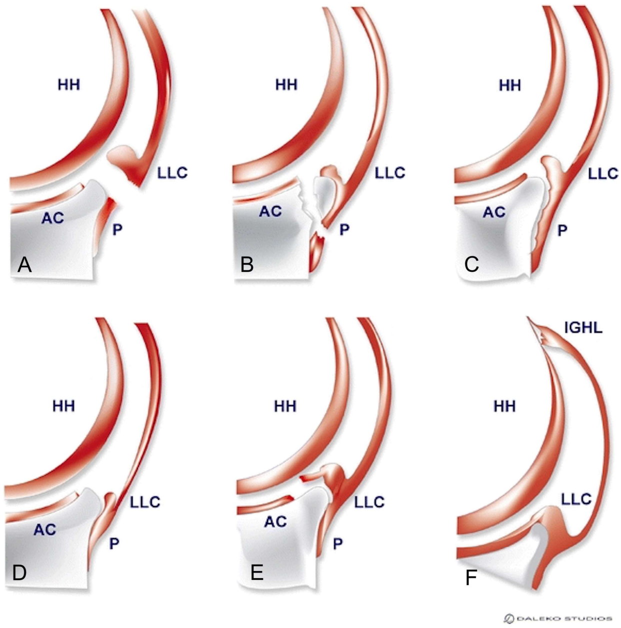

Figure 2. Classification of Bankart and Bankart variant lesions. (A) Bankart lesion, (B) Bony Bankart lesion, (C) Perthes' lesion, (D) ALPSA (anterior labroligamentous periosteal sleeve avulsion), (E) GLAD (glenolabral articular disruption) lesion, (F) HAGL (humeral avulsion of glenohumeral ligaments) lesion. LLC: Anteroinferior labro-ligamentous complex; P: Scapular periosteum; HH: Humeral head; AC: Articular cartilage of glenoid; IGHL: Inferior glenohumeral ligament. Reproduced with permission from Springer-Verlag. Woertler and Waldt. Eur Radiol 2006 (87).

RC tears and anterior glenohumeral joint capsule tears are more representative injuries after a shoulder dislocation in patients over 40 years of age (73, 88), even more so than recurrent shoulder dislocations (89). In the ageing process, the attachment of the labrum is suggested to become firmer, while the anterior glenohumeral joint capsule and RC tendons degenerate (90). Therefore, RC muscle tendons and anterior glenohumeral joint capsule may tear subsequently to a shoulder dislocation episode (73), and the prevalence increases with advancing age and recurrent shoulder dislocations (73, 89, 91, 92). RC muscle tendons may also weaken in young athletes due to debilitating, repetitive micro-trauma, and the impaired tendons may tear as a result of a shoulder dislocation (93, 94). Anterior glenohumeral joint capsule structures may strain irreversibly in a shoulder dislocation, which is clinically presented as capsular redundancy, and subsequently contribute to shoulder instability (60, 95, 96). Diminished proprioceptive function of the unstable shoulder may be caused by damage to the afferent nerve endings in the glenohumeral joint capsule, muscles, and tendons. Delayed signal production leads to impaired muscle coordination, which leads to loss of joint congruity, and predisposes to recurrent shoulder instability (60).

A shoulder dislocation may also damage bony structures, typically in the humeral head or the glenoid either alone or together, which may predispose to recurrent shoulder dislocations (7). In older patients, fractures to the greater tubercle of the humerus or to the proximal humerus may occur (89). Bony defect to the glenoid occurs most typically in the anterior glenoid (i.e. bony Bankart) (Figure 2B) and is present in 22% of primary shoulder dislocations and up to 73% of recurrent shoulder dislocations (97). Usually, the lesions are small (<20%), and they seldom have clinical relevance (7). Biomedical and clinical studies have suggested that if the anterior glenoid bone loss covers >20% of the glenoid articular surface (i.e. “inverted pear - glenoid”), it becomes clinically relevant (98-100).

Humeral head impression fracture in the posterolateral humeral head (Hill-Sachs lesion) is present in up to 88% of patients after primary shoulder dislocation and up to 100% of patients after recurrent anterior shoulder dislocations (101). However, the clinical relevance depends highly on the location and orientation of the lesion (7, 102, 103). A lesion with a size exceeding 20-30% of the articular surface of the humeral head may be a relevant contributor to recurrent shoulder instability (102). The location of the Hill-Sachs lesion has been compared with the width of the arc during glenohumeral joint motion between the glenoid and the humeral head, and the clinical relevance of the location can be elaborated with two common theories. According to the glenoid track concept, the location of the Hill-Sachs lesion on the track does not have clinical significance, as during shoulder motion the lesion does not come into contact with the glenoid rim. On the other hand, if the medial margin of the Hill-Sachs lesion is located off the track, it is possible that during shoulder motion the anterior glenoid will come into contact with the lesion, resulting in a dislocation (103, 104). However, if the long axis of the humeral head defect is parallel to the anterior glenoid when the upper extremity is in functional position in abduction and ER, the lesion may engage the glenoid and result in a recurrent event (104). In the case of bipolar bone loss, which means bone loss in both the humeral head and the glenoid, the glenoid bone loss narrows the anatomic glenoid track, which increases the probability of the medial margin of the Hill-Sachs lesion to engage (101).

A shoulder dislocation or a carelessly relocated shoulder dislocation can be associated with neurological and vascular complications and the incidence of both injuries increase with patient age (89, 105). A neurological complication has a wide spectrum of different severity manifestations and is present in 5.4-55% of cases, whereas a vascular complication is more rare and is present in about 1% of cases (106, 107). Typically, the elderly population will sustain a brachial plexus injury (BPI) after a simple fall, whereas in a younger patient population BPI most typically occurs after a high-velocity accident (107). The most commonly injured nerve in a shoulder dislocation is the axillary nerve either alone or in combination with other nerves (105, 107, 108). The highest risk for vascular injuries is in a shoulder dislocation-associated fracture of the humeral head and in elderly patients with a pre-existing arterial disease (106). Arterial injury occurs in most cases with complete or diffuse BPI (107), and vice versa, in case of an axillary arterial injury, symptomatic neurapraxia may follow in up to 60% of cases (109).

2.2.2 EPIDEMIOLOGY OF SHOULDER DISLOCATIONS

The prevalence of traumatic anterior shoulder dislocations has been estimated at 1-2% over the lifetime in the general population (48, 110, 111). The incidence of anterior dislocations varies greatly in the literature and is highly dependent on the population studied, as the incidence is higher among military personnel and athletes than in the general population (112-114). The overall incidence in the general population has been reported to be between 12.3 (8) and 56.3 (9) or in men aged under 20 years as high as 98.3 per 100 000 person-years (10). Shoulder dislocation and potential chronic instability of the shoulder are significant health issues for patients and their treating physicians (11).

About 95% of first-time shoulder dislocations are due to a clear trauma and 5% are of atraumatic origin (2). Sports-related shoulder dislocations are also quite common (4). The direction of a dislocation is in up to 98% of incidents anterior, but rarely, in about 2% of cases, posterior luxation and in <1% direct inferior luxation ("luxatio erecta") (3, 115). Prevalence of bilateral shoulder instability is about 16% (116).

In epidemiologic studies, a male under 30 years of age has reportedly been at highest risk for a primary shoulder dislocation, although a smaller but distinct peak is also present among elderly women (10, 117, 118). Several risk factors have been identified to predict the probability for recurrent shoulder dislocations and to help clinicians plan treatment. Pooled analysis of mostly low-quality studies has shown that if a patient is under 30 years of age at the time of the first shoulder dislocation episode the risk for recurrence is significantly increased (11, 12), however, the evidence to support this is only moderate (12). Similarly, male sex has been reported as a relevant risk factor (11, 12), but the evidence is deemed low (12). Presence of glenoid or Hill-Sachs lesions, mechanism of injury, reduction method, and post-reduction shoulder immobilization type or time have been associated with somewhat increased risk for recurrent shoulder dislocations, but either pooled analysis has not been possible or the evidence has not reached statistical significance (11, 12). It has also been reported that athletes are not at higher risk for recurrent instability (119), but this finding has not reached statistical significance (11, 12). Patients with an associated greater tuberosity fracture have reportedly a reduced risk for recurrence (11, 12), although the quality of evidence is considered low (12).

2.2.3 CLASSIFICATION OF SHOULDER INSTABILITY

Anatomically, a shoulder dislocation indicates a complete separation of the humeral head from the glenoid, whereas a subluxation is translation beyond normal limits with some contact maintained between the humeral head and the glenoid. The dissociation of dislocation is present in radiographs or requires a manual closed reduction, whereas in the case of a subluxation, a reduction manoeuvre is not required and radiographs are normal (120).

The classification of shoulder instability for clinical use should be simple and easy to use (77, 121), with good content validity and high intra-observer and inter-observer agreement (121). The literature provides numerous definitions and classifications for shoulder instability (77, 121). The heterogenic use of definitions and classifications can make comparison of different treatment methods difficult or even impossible (121) and has led to misdiagnosed patients and poor agreement between physicians (122, 123). Simplistically, a patient can experience "discomfort and a feeling of looseness, slipping, or the shoulder 'going out' to meet the definition of instability" (121).

2.2.4 CLINICAL PRESENTATION OF SHOULDER INSTABILITY

The initial reason for the patient with shoulder instability to seek medical council is generally fear of shoulder dislocation when the upper extremity is used. But mere pain in the shoulder can be a sign of shoulder instability, especially in patients under 40 years of age (77, 124). The majority of all shoulder instability events are subluxations, and frank dislocations are more rare (113, 125, 126). After a first-time shoulder dislocation, the clinical presentation has a great variation from asymptomatic to symptoms exclusively in a particular at-risk position to interfering with normal daily activities (21). If after the primary incident the injured structures heal in a way that the shoulder remains functionally stable, it can be assumed that the disease ends at that point. However, in the case of improper healing, the dynamic stabilizers are inadequate to maintain shoulder stability, and hence, a recurrent event can be expected (127). Alternatively, a recurrent event may never happen, but there is a constant feeling of apprehension, weakness, or pain in the shoulder, which decreases the patient's QoL (22). The patient may also develop kinesiophobia, which may become an insurmountable obstacle to engaging in the event during which the primary dislocation occurred or circumstances similar to it (128). On the other hand, the patient may suffer recurrent dislocations, but consider them only a nuisance (13).

2.2.4.1 Asymptomatic shoulder hyperlaxity

Symptomatic instability is paramount for the diagnosis of shoulder instability, otherwise, the condition should be referred to as merely asymptomatic shoulder hyperlaxity (60, 121), which does not require further investigation or treatment (129, 130). Shoulder hyperlaxity is mostly congenital without a systemic disease or collagen-tissue disorder, but it can also be acquired (131). In the acquired condition, hyperlaxity is due to repeated minor injuries (micro-traumas) or repetitive use during training or overhead work, which stretch normal capsuloligamentous structures (21). Acquired hyperlaxity is commonly unilateral, while other joints do not present hyperlaxity (2, 6, 16, 21). There is enormous variation in the range of normal shoulder laxity, and even asymmetry of humeral translation on the glenoid between the patient's shoulders does not automatically indicate shoulder instability. Even the ability to asymptomatically subluxate a shoulder over the glenoid rim has been considered a normal variant (121, 132). Humeral translation on the glenoid is required for normal ROM, thus, translation can be anywhere between slight and substantial in normal, symptomless subjects similarly to patients suffering from shoulder instability (133, 134).

2.2.4.2 Atraumatic shoulder instability

Congenital hyperlaxity may predispose to development of atraumatic instability (25), or the instability can be acquired atraumatically (21). The condition can be unidirectional or present instability in two or more directions. If symptoms are present in two or more directions, the condition is generally referred to as multidirectional instability (MDI) (25, 131). If the condition is due to congenital hyperlaxity, it is often bilateral (135). Acquired instability is mostly due to (repetitive) microtrauma, (rarely) an acute (or multiple) major trauma, or a combination of these. An atraumatic event may occur when a patient is moving the extremity or while asleep (2). Characteristically, patients with atraumatic shoulder instability experience subluxations rather than dislocations, and the structural lesions of traumatic shoulder dislocation are more generally absent (6, 21).

2.2.4.3 Post-traumatic shoulder instability

In case of traumatic shoulder dislocation, the patient typically describes a direct blow onto an abducted, externally rotated, and outstretched arm (6, 15, 16, 63, 136), but in the elderly population a shoulder dislocation is typically due to a low-energy fall (6, 137). After a clear traumatic shoulder dislocation, patients experience usually unilateral and unidirectional recurrent dislocations or subluxations due to a structural weakness provoked by the injury to the capsulolabral complex (21).

2.2.5 DIAGNOSIS OF SHOULDER INSTABILITY

2.2.5.1 Patient history and clinical examination

For the diagnosis of shoulder instability, a detailed clinical history and a full examination are critical (6, 16, 138). The patient should be asked to describe the primary shoulder dislocation, and in case of traumatic origin, to provide as specific a description about the event as possible. The patient's age at the time of the first dislocation, the duration of symptoms, and the direction and number of dislocations before seeking help are also considered relevant information (16, 138). The ability to volitionally dislocate the shoulder (i.e. "party trick") must be identified (139).

For the physical examination, the patient's upper body should be undressed. The posture of the patient, asymmetry of the shoulders, and atrophy of the deltoid or RC muscles must be assessed. The index shoulder is inspected and palpated, and the findings should always be compared with the contralateral shoulder (6, 16, 77, 138, 140). ROM is tested and reported in degrees actively and passively. Strength, pain, and weakness are tested in abduction, ER and IR, and in RC muscles separately. Presence of generalized hyperlaxity (e.g. hypermobile patella or hyperextension of elbows and metacarpophalangeal joints, and ability to reach the ipsilateral forearm with the abducted thumb) must be assessed (138).

An array of clinical tests is available for assessment of the shoulder. The tests are mainly poorly repeatable, as according to a recent Cochrane analysis, only six test-diagnosis combinations were interpreted similarly in two different publications and no combinations were interpreted similarly in another three publications (141). For assessing shoulder instability, only a few tests have shown good utility. Due to the lack of evidence regarding reproducibility of clinical tests to assess shoulder instability, a combination of tests should be used for detecting various pathologies (142).

Anterior shoulder instability can be evaluated with apprehension, relocation, and surprise tests (143-145), which have shown good clinical utility and high sensitivity and specificity in a pooled analysis (142). An apprehension test is performed with the examined extremity in 90° abduction and maximal ER. If the patient experiences apprehension (i.e.

subjective feeling of the shoulder dislocating) after a gentle anteriorly directed force, the test is positive. A relocation test is performed after a positive apprehension test. If at the point of apprehension, a posteriorly directed force relieves the feeling, the relocation test is positive. In the surprise test, the patient lies supine with the examined extremity in 90° abduction. The extremity is externally rotated and simultaneously a posterior gentle force is applied. If the posterior force is suddenly removed and the patient experiences pain and apprehension, the test can be regarded as positive (16, 138).

2.2.5.2 Radiographic evaluation

Diagnostic imaging is used to support clinical findings from the examination and to better demonstrate the pathoanatomy of the shoulder dysfunction (146). Pre-reduction radiographs are recommended in all first-time shoulder dislocations, in patients over 40 years old, and in shoulder dislocations following high-energy trauma (15) before any attempt at manipulation and reduction is made (147), to confirm the dislocation and the presence of any associated fractures (6, 15). Post-reduction radiographs are recommended both to ensure successful reduction and to confirm that no fracture has been caused by the relocation or missed in pre-reduction radiographs (6, 15, 148).

Magnetic resonance imaging techniques are commonly used when evaluating intra- and extra-articular soft tissue pathology in shoulder instability. MR arthrography (MRA) is superior to conventional MR imaging (MRI) in evaluation of glenohumeral joint lesions (146). However, computed tomography (CT) is still the preferred method, providing very good agreement among users in identifying the size, location, and type (fracture or erosion) of glenoid defects associated with anterior shoulder instability (77, 149-151).

2.2.6 SHOULDER FUNCTION ASSESSMENT

Traditionally, patient outcomes have been evaluated objectively with radiographs, ROM, strength, and pain (43, 44), but these outcomes and their significance are highly dependent on the way of measuring and interpreting the results (43). Moreover, these outcomes indicate poorly the functional and psychological aspects of health (44). Also, generic instruments respond poorly when evaluating function or QoL after a certain treatment (e.g. shoulder instability repair). Specific instruments have been developed to assess a condition (e.g. shoulder instability), a region of the body (e.g. upper extremity), or a function (e.g. shoulder) -dependent outcome (44).

Numerous tools are available to assess patients with shoulder problems (152, 153), but it is crucial to comprehensively evaluate the condition, disability, and recovery with an appropriate set of generic health instruments and subjectively and objectively scored measurement tools (43, 154, 155).

2.2.6.1 Shoulder scores

Oxford Shoulder Instability Score (OSIS) (156), Rowe score (157), and Western Ontario Shoulder Instability Index (WOSI) (110) are popularly used shoulder instability specific measurement tools. According to a systematic review (SR) of shoulder-specific outcome measures (153), highest reliability, validity, and responsiveness with shoulder disorders was rated in American Shoulder and Elbow Surgery Standardized Shoulder Assessment Form (ASES) (158), Simple Shoulder Test (SST) (159), and Oxford Shoulder Score (OSS) (160), but Shoulder Pain And Disability Index (SPADI) also showed acceptable properties (161). Additionally, Constant Score (162), Disabilities of the Arm, Shoulder and Hand (DASH) (163), and University of California Los Angeles Shoulder Rating Scale (UCLA) (164) are widely used in assessment of shoulder disability (110, 152, 155, 165). Shoulder instability-specific measurement tools and general shoulder scores are presented in Table 1.

Table 1. *Shoulder instability-specific measurement tools and general shoulder scores.*

Shoulder instability-specific measurement tools	Assessor	Objective	Description	Reliability	Responsiveness (for shoulder complaints)	MCID (for general shoulder complaints or shoulder instability)
OSIS(156)	Patient	Shoulder instability symptoms	12 items (Likert scale)	Excellent(166)	Very good(166)	9(167)
Rowe(157)	Physician	Postoperative objective assessment of LR	3 items (Likert scale: Stability, Motion, Function)	Fair(166)	Very good(166)	Not established
WOSI(110)	Patient	Shoulder instability-related shoulder function	21 items (VAS: 10 Physical symptoms, 4 Sport, recreation, work, 4 Lifestyle, 3 Emotion)	Excellent(166)	Excellent(166)	220(44)
General shoulder scores						
ASES(158)	Physician and patient	Shoulder pain and function	11 items (1 Pain (VAS), 10 Function)	Excellent(166)	Excellent(166)	6.4(166)
Constant score(162)	Physician and patient	Shoulder ROM, strength, and subjective evaluation of function	10 items (4 Motion, 1 Strength, 1 Pain, 4 ADL)	Very good(166)	Excellent except for shoulder instability(166)	10.4(166)
DASH(163)	Patient	Any condition of any joint in upper extremity	30 items (21 ADL, 5 Pain, tingling, weakness, 4 Impact on social activities	Excellent(166)	Excellent(166)	10(166)
OSS(160)	Patient	Outcomes of shoulder surgery (excluding shoulder stabilization)	12 items (Likert scale: 4 pain, 8 function)	Not evaluated	Limited evaluation(152)	Not established
SPADI(161)	Patient	Pain and disability in a painful shoulder	13 items (NRS: 5 pain, 8 disability)	Excellent(152)	Very good(152)	Not established
SST(159)	Patient	Physical function and subjective evaluation	12 dichotomous items	Excellent(166)	Limited evaluation(166)	Not established
UCLA(164)	Physician	Shoulder arthroplasty	5 items (1 Likert pain scale, 1 function, 2 ROM, 1 subjective satisfaction evaluation with a dichotomous item)	Not evaluated	Limited evaluation(166)	Not established

ADL: Activities of daily living; ASES: American Shoulder and Elbow Surgery Shoulder Score; DASH: Disabilities of Shoulder and Hand; LR: Labrum repair; MCID: Minimal clinically important difference; NRS: Numeral rating scale; OSIS: Oxford Shoulder Instability Score; OSS: Oxford Shoulder Score; SPADI: Shoulder Pain and Disability Index; SST: Simple Shoulder Test; ROM: Range of motion; UCLA: University of California and Los Angeles Shoulder Score; VAS: Visual Analogue Scale; WOSI: Western Ontario Shoulder instability Index.

2.2.7 TREATMENT OF TRAUMATIC SHOULDER INSTABILITY

The goal of treatment after a traumatic shoulder dislocation is to restore a functional, painless, and stable shoulder with maximum ROM (13, 14). Patient's age, occupation, activity level, ligamentous laxity, general health, and cooperation should all be taken into account and thoroughly discussed with the patient when the optimal treatment approach is chosen (14, 168).

When a patient seeks help for management of a musculoskeletal condition, surgery is reported to be performed more often if the treating physician is a surgeon versus a non-surgical specialty (169), and if the evidence for the effectiveness of surgery is unclear the surgeons more regularly recommend surgical treatment (28).

2.2.7.1 Acute shoulder dislocation and reduction

When a shoulder dislocates, the reduction should be performed without delay either on the field or in the emergency department for the easiest reduction and minimization of the risk for neurovascular injuries (13). Also, the longer the delay, the more difficult and painful the reduction is for the patient (170). Adequate analgesia and relaxation of the patient will more likely lead to a successful reduction (13, 15). According to a recent Cochrane analysis, intra-articular block results in a comparable success rate and analgesia as intravenous sedation and could be preferred (171).

Many successful reduction techniques have been reviewed (13, 15), and it has been suggested that the reduction technique chosen should depend on the patient's preference and the clinician's familiarity with each technique (13). The relocation techniques can be divided into two major groups: leverage (e.g. Kocher's (172) and Milch's (173) methods) and traction (e.g. Hippocrates, Stimson (174), or scapular manipulation techniques (175)) (15).

Rarely, an acute traumatic shoulder dislocation is irreducible and requires open reduction. This typically concerns male patients in their fourth decade and is due to a structural obstacle such as soft tissue entrapment, glenoid or greater tuberosity fractures, or a large Hill-Sachs lesion (176).

2.2.7.2 Non-surgical management of shoulder instability

Muscle strengthening is the primary focus in rehabilitation of shoulder instability (24). The evidence of successful non-surgical management (NSM) as a structured rehabilitation programme in treatment of a first-time shoulder dislocation is limited and relatively old (177). Promising results of rehabilitation are mainly shown only in treatment of patients with atraumatic shoulder instability (3, 178, 179), but evidence of the effectiveness is of very low quality (180). Pooled analysis of structured programmes has been impossible in treatment after primary shoulder dislocation due to the poorly reported nature, duration, and structure of the protocols (136). Typically, the patient is instructed to engage in gradually progressive exercises with the goal of full strength and ROM (13, 22, 168, 181). If the patient suffers from recurrent shoulder dislocations or symptomatic shoulder instability despite appropriately performed physiotherapy for at least six months (25), surgery can be considered (16). Patients with signs of hyperlaxity should primarily be treated non-surgically, even with additional structural damage (77). In the case of volitional instability, surgery should be contraindicated (182, 183). Surgical management of shoulder instability in the patient population with psychological or secondary gain issues may result in high rates of recurrence (121, 138).

There is ongoing debate about the optimal management of patients sustaining primary shoulder dislocation (26, 27). After a successful reduction of the shoulder, the affected extremity should be immobilized to heal injured soft tissues. Usually, immobilization in a sling or a collar and cuff with shoulder in adduction and IR has been suggested (13, 15, 16), but arm position in ER has been reasoned to provide a better position for the torn labrum against the glenoid in imaging studies (184, 185). Optimal duration of immobilization of three to four weeks is suggested (13), however, immobilization in IR after a primary shoulder dislocation for over one week has not reduced recurrent instability episodes (186, 187). According to pooled analyses of randomized controlled trials (RCTs), arm position in ER has not proven superior to conventional immobilization in IR in reducing recurrent instability episodes after the primary shoulder dislocation (17-19).

2.2.7.3 Surgical treatment of shoulder instability

After a first-time shoulder dislocation, the opinion on preferable treatment strategy varies considerably (26, 27). It has been suggested that surgical treatment should be performed already after the primary shoulder dislocation because young men, especially those involved with sports, are at significant risk of recurrent dislocation (14, 30, 188). The surgical procedure of choice can be performed as an open or arthroscopic procedure, and repair of the lesion(s) as an anatomic (i.e. capsulolabral repair) or non-anatomic (i.e. bone block) procedure, depending on the severity of the soft tissue lesions and the degree of bone loss (32). If an anatomic repair is performed, it is generally referred as a Bankart repair as a historical tribute.

Due to the advancement and popularity of arthroscopic surgery, if surgery is required, an arthroscopic LR is usually performed after a first-time shoulder dislocation and in treatment of chronic post-traumatic shoulder instability to prevent subsequent shoulder instability episodes (32). The LR aims to restore the normal anatomy by reattaching the torn, anterior capsulolabral complex to the glenoid neck (189). The surgical techniques of open and arthroscopic LR have evolved significantly since their introduction, but most importantly, the fixation method of the labrum to the glenoid has changed from silk sutures used by Bankart (81) to stapling (190), transosseus sutures (191, 192), metallic rivets (193), transglenoid tacks (194), and most recently, suture anchors (195-197). The most distinct difference between the open and arthroscopic methods is that, if the open method is used, the subscapularis muscle tendon must be incised to access the glenohumeral joint capsule.

The fixation materials can be divided into absorbable and non-absorbable categories. Non-absorbable implants provide a definite fixation to enable the repaired tissue to heal, whereas absorbable implants provide intuitively fixation for the limited period in which the healing is anticipated to occur (198). The degradation time in which an absorbable implant is broken down and excreted is dependent on the implant material (199). High recurrence rates have been associated with earlier methods of fixation and implant materials (200, 201), however, according to a recent MA, the fixation method may not have had a relevant impact on recurrence rates even with the older techniques (200). Also according to published RCTs, the recurrence rates are similar with absorbable and non-absorbable implant types (198, 199, 202). Probably more important factors for successful treatment are identification and understanding of the relevance and treatment of the concomitant pathology (32) and accurate placement of implants (203). No consensus has been reached on an adequate number of suture anchors, but generally at least three anchors are used to ensure fewer recurrent instability episodes (32, 189, 204).

The evidence of effectiveness of surgery after the primary traumatic shoulder dislocation has been studied in several RCTs with inconsistent conclusions (22, 48, 50, 181, 205, 206). Some authors have suggested that due to a high risk for a young athlete to suffer a recurrent event surgical intervention should be performed already after the first-time traumatic shoulder dislocation (14, 30, 188). LR after the primary dislocation has also been reasoned to reduce treatment costs (50, 207). Surgery (open and arthroscopic LR) has been favoured over NSM in terms of fewer recurrent instability episodes in published MAs (14, 30, 31), but the analyses have included retrospective cohorts, quasi-RCTs, and unpublished studies.

Currently, there are no NMAs that have assessed different surgical interventions (LR and arthroscopic lavage, AL) and NSM in the same setting. In general, it is unknown whether it is reasonable to perform a stabilization procedure already after the primary traumatic shoulder dislocation. In treatment of chronic post-traumatic shoulder instability, effectiveness (i.e. recurrent dislocation rate) has been reported to be either similar with open and arthroscopic fixation methods (31, 200, 208-213) or lower in favour of the open fixation method in MAs, including several studies of a low level of quality (214-216). Currently, there are no RCTs that compare the effectiveness of surgery versus non-surgical interventions in treatment of chronic post-traumatic shoulder instability, and therefore, the optimal treatment strategy remains obscure. The absorbability of implants and suture materials have been studied in RCTs in treatment of chronic post-traumatic shoulder instability, and no significant difference in any outcome between materials has been observed (198, 199, 217, 218).

Concomitant lesions in soft tissues or in bony structures can be present already after the primary shoulder dislocation, but the occurrence increases with recurrent events (219, 220). Mostly, the concomitant lesions can be treated arthroscopically, but depending on the surgeon's experience and the extent of pathology, open surgery may be required (32). If a Hill-Sachs lesion, which is deemed clinically relevant, is present, it can be filled with bone allograft (221) or covered with soft tissue by a method known as remplissage (222). It has been suggested that glenoid bone loss of over 20% indicates an open coracoid transfer (197), which can be combined with a humeral side procedure (bone graft or remplissage) if the Hill-Sachs lesion is in a risk area (223).

An open coracoid transfer (i.e. the Latarjet technique), a bone block procedure, was developed to treat shoulder instability in 1954 (224), and it was later learned that the procedure can effectively treat patients with significant bone loss. Nowadays, the most significant indication for a Latarjet procedure is anterior glenoid bone loss (225), but it can also be used if a patient presents with bipolar bony defect (223). The procedure has several modifications, but in general, osteotomy of the coracoid is performed, and the bone block is attached with screws with its long axis perpendicular to the anterior glenoid. The bone block increases the diameter of the injured anterior glenoid, and the muscles attached to the coracoid (i.e. conjoined tendon) create a sling to strengthen the anterior capsule in abduction and ER (224, 226), and provide blood supply to the bone transfer (197). The Latarjet operation can also be performed arthroscopically (227), but the technique has a steep learning curve (228, 229), and therefore, the open method is more widely in use. The Latarjet technique is rarely required and nowadays seldom in use after the primary shoulder dislocation (220), but in treatment of chronic post-traumatic shoulder instability, the recurrence rate is lower than with anatomic LR (230, 231).

Recurrent instability may persist after a primary surgical intervention if glenohumeral bone deficiency has not been recognized or treated (104) or if the patient has ligamentous hyperlaxity (203). Also male sex, patient's age of under 20 years, incidence of bilateral dislocations, Caucasian race, and increased number of closed reductions before the primary operative procedure have shown a higher risk for failure (i.e. recurrent shoulder instability) of the stabilization procedure (232), especially if arthroscopic fixation methods are used. Balg and Boileau developed an Instability Severity Index Score (ISIS), which aims to identify patients who would benefit from a primary bone block procedure (233). The pre-operative use of the score has proven to be valuable in recent publications (234-236).

The revision shoulder instability surgery can be performed as open or arthroscopic LR or Latarjet repair. Revision arthroscopic LR was compared with revision open LR in an SR of follow-up studies, and the outcome results were similar (237). Generally, revision arthroscopic LR has shown good to excellent results in carefully selected patients, but there is a limited evidence of its effectiveness (238). The recurrence rate after a revision Latarjet procedure has been evaluated seldom, but in general the recurrence rate in retrospective follow-up studies has been considered acceptable and similar to that with arthroscopic LR (230, 239, 240).

2.2.7.4 Surgical trends

The current trend is to perform shoulder stabilization surgery arthroscopically, and the proportion has rapidly increased up to 92% during the beginning of the 21st century (34-40), even though the increase in popularity is not supported by scientific evidence (211, 213, 215, 241). To explain the popularity of arthroscopic procedures, the following have been suggested: surgical trends (38), improved imaging technologies (41), financial motivation (38), and patients' anticipation of a superior outcome with arthroscopic procedures (42). At the same time as arthroscopic procedures, anatomic repair methods have gained immense popularity, the incidence of open anatomic repair has decreased, and the incidence of non-anatomic (i.e. Latarjet) procedures has increased (34, 36, 39, 40, 242). The trend of shoulder capsular surgery procedures or the distribution between publicly and privately funded hospitals has not been studied and reported in Finland.

2.2.7.5 Adverse effects

Complications are present in surgery of any kind (243). However, complications related to surgery are underreported and difficult to evaluate since the term complication itself may have various definitions (244, 245). In the published literature, adverse effects have been weakly and heterogeneously reported, which has made pooled analyses impossible (208, 246).

Overall complication rates related to arthroscopic shoulder surgery range between 4.6% and 10.6% (247), but the risk of serious harms (e.g. mortality, septic shock, deep infection, deep vein thrombosis) following mixed arthroscopic shoulder procedures is low, as according to two registry studies the complication rate of serious harms was 0.55% in 2006-2011 (248, 249). The complication rates between arthroscopic and open LR have also been reported to be similar (201). The complication profile after NSM of a primary shoulder dislocation in the published RCTs consists mostly of transient shoulder pain and rigidity in 1-10% of cases (46, 47, 181, 250), but also adhesive capsulitis (2%) (50) and axillary rash (8%) (251) has been reported to occur.

Coracoid transfer techniques have been described to have a high complication rate of up to 30% (252), which exceeds that with anatomic repair methods (253). The complications are mostly related to hardware failure (e.g. screw migration, misplacing, loosening, and breakage) or the graft used (e.g. non-union, fibrous union, osteolysis, graft fracture, graft migration) (252, 254). The complication rates between open and arthroscopic coracoid transfer techniques have been reported to be similar in an SR of mostly prospective cohorts (254).

Metallic non-absorbable fixation materials are no longer widely in use due to the risk of loosening, migration, and chondral damage (255-257). Bioabsorbable fixation materials can, on the other hand, cause foreign body reactions, osteolysis, synovitis, chondrolysis, migration, and implant failures (258-261), but the overall complication rate is considered low (258).

2.2.8 LONG-TERM RESULTS AND SEQUELAE

Shoulder dislocation may have short- and long-term implications, including increased mortality rates, for patients (45). Recurrent shoulder instability has been speculated to cause occupational limitations, socioeconomic impacts, increased medical costs, potential loss of income, and a decrease in general QoL (126, 262, 263).

Shoulder instability-related shoulder function has been rarely studied (22, 46-52), and, if studied, baseline scores have seldom been reported (49, 52). Only in one RCT was a clinically relevant improvement in instability-related shoulder function (WOSI) reported at two years in favour of surgical intervention after primary shoulder dislocation (22). In addition, a statistical but not clinical difference was reported in two other RCTs (46, 50). However, mostly no statistical difference between groups in WOSI scores was observed after a first-time shoulder dislocation or recurrent shoulder instability (47, 49, 51, 52). Shoulder function assessment has generally been heterogeneously studied with different questionnaires and clinical assessment methods in the published RCTs (22, 46-52, 181, 198, 199, 205, 206, 217, 218, 250, 251, 264-271). Due to this heterogeneity, a pooled analysis has been performed only on Rowe score with mixed findings (209, 210, 246).

Primary glenohumeral OA has been considered somewhat rare (53). However, glenohumeral OA may progress to a dislocated shoulder within several years, and the risk factors proposed for the condition are patient's age of over 25 years at the time of first shoulder dislocation, high-energy mechanism of injury, and alcohol abuse (54). The risk of severe OA may be as high as 10- to 20-fold among patients who have dislocated their shoulders compared with those who have not (272). Repeated shoulder dislocations prior to surgical intervention may increase the prevalence of glenohumeral OA (55). The role of surgery or the technique used is probably not relevant to the prevalence or severity of glenohumeral OA (54, 56), although the OA has been speculated to have some relationship in poorly or misplaced suture anchors with the arthroscopic technique (244). According to the literature, the glenohumeral OA is most commonly classified as mild, but the published literature also includes non-anatomical repairs (54), with no special focus on arthroscopic labrum fixation techniques. The role of arthroscopic fixation of traumatic shoulder instability in glenohumeral OA or shoulder function is unknown.

2.3 CHANGE OF REIMBURSEMENT SYSTEM IN OCCUPATIONAL AND TRAFFIC INSURANCE IN FINLAND

In Finland, employers are obligated to take out statutory workers' compensation insurance to cover their employees against occupational injuries and diseases. The statutory workers’ compensation insurance is administered by private accident insurance companies. Previously, the insurance companies paid an estimated tax of 50,000,000 € from workers’ compensation insurance to the public health care system to cover the expenses due to patients’ treatment, and the patients were mainly referred to public hospitals for treatment.

A significant change in the reimbursement system of the Finnish occupational and traffic insurance health care system occurred in 1.1.2005. Since 2005, the pre-estimated tax was no longer paid, and insurance companies started to pay the actual costs of treatment. The insurance companies were also entitled to direct the patients to a self-chosen service provider in order to minimize delays in patients' care and rehabilitation.

Generally, in private hospitals in Finland, the surgeons' salary correlates with the number of performed surgical procedures, whereas in public hospitals the surgeons receive a fixed salary. The ease of billing has been considered to be partly responsible for the rising incidence of certain surgical procedures (38, 273, 274), and financial incentives might also be partly responsible for increased surgery rates in private hospitals in Finland (275). It has been speculated that while insurance companies reimburse certain procedures only if performed due to traumatic origin of injury, the overestimation of lesions interpreted to be of traumatic origin may also lead to increased incidence of procedures (276, 277). As the incidents leading to shoulder capsular surgery are often of traumatic origin, but the treatment is rarely urgent, the policy change may have directed those patients not requiring emergency treatment to private hospitals.

This natural experiment may have had an impact on the distribution of shoulder capsular surgery interventions between publicly and privately funded hospitals since only in privately funded hospitals is there a clear incentive to increase numbers of procedures in order to gain financial benefit.

3 AIMS OF THE STUDY

The purpose of this thesis was to evaluate the evidence, the surgical trends, and the long-term effects of treatment of traumatic shoulder instability. The following specific points were addressed:

1) To systematically evaluate the quality of evidence in treatment of a first-time traumatic shoulder dislocation and chronic post-traumatic shoulder instability with a meta-analysis and a network meta-analysis (I).
2) To investigate the incidence rates of shoulder capsular surgery procedures in Finland between 1999 and 2008 and to determine the differences in procedure incidences by geographical location and the changes in incidence by different age groups (II).
3) To evaluate the trends in incidence of shoulder capsular surgery in Finland after the change in the reimbursement system in 2005 between publicly and privately funded hospitals. A secondary aim was to determine whether there was variation in the procedure incidences between different age groups (III).
4) To assess long-term prevalence of glenohumeral OA and shoulder function after arthroscopic labrum repair with bioabsorbable tacks (IV).

4 METHODS

4.1 SYSTEMATIC REVIEW AND NETWORK META-ANALYSIS (I)

MA is a statistical method to quantitatively synthesize clinically homogeneous studies from an SR; however, it can only be used to compare two interventions evaluated directly in a head-to-head trial at one time (direct evidence). NMA is a relatively new and more advanced method that enables analysis of multiple treatments in a single analysis using both direct and indirect evidence. Indirect evidence is obtained for different treatment modalities through one or more common comparators (278).

Our SR was constructed by following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline (279). The study was registered in an international prospective register of SRs (PROSPERO) (registration ID: CRD42015020303). We used the term ‘dislocation’ to refer to a true dislocation of the shoulder, and dislocations, subluxations, or other symptoms of shoulder instability either alone or together are referred to as ‘symptomatic instability’. Both ‘recurrent dislocation(s)’ and ‘redislocation(s)’ are used to indicate one or more dislocations after the primary shoulder dislocation, and chronic post-traumatic instability indicates dislocation(s), subluxation(s), and other symptoms of instability after the primary shoulder dislocation.

4.1.1 DATA SOURCES AND SEARCHES

We conducted our final update of the systematic literature search on 15 January 2018 in the following databases: Ovid MEDLINE®, Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, Embase, Scopus, CINAHL, Ovid MEDLINE® Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE® Daily, Database of Abstracts of Reviews of Effect (DARE), Health Technology Assessment Database, NHS Economic Evaluation Database, and Web of Science. We adjusted the search strategies to meet specific requirements of individual databases. Additional possibly relevant publications or earlier reviews that were missed in the electronic systematic search were screened from the reference lists of the included studies. From the International Clinical Trial Registry Platform (ICTRP) maintained by the World Health Organization (WHO), we sought registrations of ongoing and possibly completed but unpublished studies on 23 January 2018.

4.1.2 STUDY SELECTION

We included only RCTs in the SR. We aimed to study the whole continuum of shoulder instability, and therefore, we accepted all treatment comparisons after a first-time traumatic shoulder dislocation or chronic post-traumatic shoulder instability with a follow-up of at least one year and an outcome measure related to shoulder instability, shoulder function, or patient's QoL. Studies on atraumatic shoulder instability, cadaveric or biomechanical studies, and studies on secondary shoulder instability (e.g. neurological conditions, syndromes, or congenital conditions), conference abstracts, and publications with no available source data were excluded. Two investigators independently assessed all identified publications for eligibility and resolved any disagreements by consensus.

4.1.3 DATA EXTRACTION AND RISK OF BIAS ASSESSMENT

We categorized the publications included according to the two clinical scenarios under review (first-time traumatic shoulder dislocation and chronic post-traumatic shoulder instability). We extracted the outcome data for all follow-up assessments in these studies. For the analysis on first-time shoulder dislocation, we used redislocation data from one-year and two-year follow-ups, as defined in the individual studies. We extracted the data from figures and survival-rate graphs if numeric outcome data were unavailable.

In addition to the outcome measures, we extracted trial registry identifiers, study objectives, inclusion and exclusion criteria, number of patients allocated to intervention and control groups, follow-up time, sex distribution, mean age, proportion of sports injuries, indications for surgery, treatments for the intervention and control groups, associated soft tissue and bony injuries, pre-specified and reported harms, sample size estimations, study sponsorships, and conflict of interest (COI) statements from the studies. We sent emails to authors of potentially eligible conference abstracts, publications with no available source data, and unpublished trials and inquired about the status of the trial and requested data to be included in the MAs.

For the risk of bias assessment, we extracted the method of randomization and randomization sequence generation, allocation concealment, degrees of blinding, loss to follow-up, intention-to-treat (ITT) analysis, selective reporting, similarity of patient groups, co-interventions, compliance, and timing of the outcome assessment. Two reviewers independently extracted all data to a customized worksheet.

Two reviewers independently assessed the risk of bias among the studies included according to the guidelines of the Cochrane Back Review Group. The risk of bias assessment has 12 independent criteria, each with a judgement of 'yes', 'unclear', or 'no'. We considered the risk of bias in the publications as low if at least six of the 12 criteria were judged to be at low risk of bias ('yes') (280).

We compared the outcome measures specified in the methods section of the publication and in the trial registry (if available) with those reported in the results section of the publication to evaluate potential selective outcome reporting. For an acceptable range in the analysis of the timing of the outcome assessment, we permitted a deviation of three months (in a two-year follow-up). If the two reviewers encountered disagreements on the retrieved data, they were resolved by consensus. For unclear items, we contacted the authors by email for clarification.

Researcher COI and industrial sponsorship have been identified as potential sources of bias (281-283), which were assessed and considered in the studies.

4.2 PATIENTS (II, III, IV)

Studies II and III were performed on the whole population of Finland, excluding the Åland islands. Health care on the Åland islands is partly organized in Sweden, which was the reason for the exclusion. The population of Finland was 5,150,000 in 1999, increasing to 5,300,000 at the end of the study period in 2008. We gathered the annual populations in predetermined age groups (<20, 21–30, 31–40, 41–50, 51–60, and >61 years) and in university hospital districts from the Official Statistics Finland (284). Finland is geographically divided into five university hospital districts: Helsinki, Tampere, Kuopio, Oulu, and Turku. The population in the university hospital districts in 2008 varied between 691,000 and 1,810,000.

We identified and included shoulder capsular surgery patients operated on for all kinds of shoulder instability or after a shoulder dislocation in public and private hospitals in Finland during a 10-year period between 1 January 1999 and 31 December 2008 from the Finnish Hospital Discharge Register (FHDR) and from the reimbursement register of the Social Insurance Institution. To secure the most accurate number of performed shoulder capsular surgery procedures, we included any of the International Classification of Diseases, Tenth Edition (ICD-10) diagnoses and primary Nordic Medico-

Statistical Committee (NOMESCO) procedure code combinations presented in Tables 2 and 3, respectively. The use of NOMESCO procedure codes is dependent on the translation, and unfortunately, the translations are not implicit. Therefore, a procedure code may be in use for different procedures in different countries. According to the Finnish translation, it is not possible to distinguish whether a specific part of the labrum is operated on, and therefore, the meticulous use of the procedure codes varies also in Finland among individual institutions and surgeons.

Table 2. *Relevant ICD-10 codes and explanations according to the Finnish translation. Clinical problem (reason for shoulder capsular surgery) arises from the combination of ICD-10 code and surgical procedure code (NOMESCO).*

ICD-10 code	Translation from Finnish to English	Direct English version of the ICD code	Clinical problem among patients with shoulder capsular surgery
S42.1	Fracture of scapula (bony labrum lesion)	Fracture of scapula	Instability due to bony labrum lesion
S43.0	Dislocation of shoulder joint	Dislocation of shoulder joint	Dislocation of shoulder joint
M24.2	Disorder of ligament	Disorder of ligament	Dysfunction of ligament in shoulder capsular complex
M24.4	Recurrent dislocation or subluxation of joint	Recurrent dislocation and subluxation of joint	Recurrent dislocation or subluxation of joint
S43.4*	Sprain or strain of shoulder joint	Sprain and strain of shoulder joint	Instability or SLAP of the shoulder after shoulder sprain
S43.7*	Sprain or strain of other or unspecified parts of the shoulder girdle	Sprain and strain of other and unspecified parts of shoulder girdle	Instability or SLAP of the shoulder after shoulder sprain

ICD-10: International Classification of Diseases, Tenth Edition; SLAP: Superior Labrum Anterior to Posterior; NOMESCO: Nordic Medico-Statistical Committee. Reproduced with permission from SAGE Publications. Kavaja et al. Scand J Surg 2018. (II, III)

**Included only as secondary ICD-10 codes.*

Table 3. *Relevant surgical procedure codes (NOMESCO) and explanations according to the Finnish translation.*

NOMESCO procedure codes	English translation from Finnish version of procedure codes	Direct English version of the procedure code
NBE20	Suture or reinsertion of ligament of shoulder	Suture or reinsertion of ligament of shoulder
NBE25	Arthroscopic suture or reinsertion of ligament of shoulder	Arthroscopic suture or reinsertion of ligament of shoulder
NBE30	Transposition of ligament of shoulder	Transposition of ligament of shoulder
NBE35	Arthroscopic transposition of ligament of shoulder	Arthroscopic transposition of ligament of shoulder
NBE40	Repair or transplant of shoulder capsule or ligament of shoulder	Plastic repair of ligament of shoulder not using prosthetic material
NBE45	Arthroscopic repair or transplant of shoulder capsule or ligament of shoulder	Arthroscopic plastic repair of ligament of shoulder not using prosthetic material

NOMESCO: Nordic Medico-Statistical Committee. Reproduced with permission from SAGE Publications. Kavaja et al. Scand J Surg 2018. (II, III)

To exclude multiple admissions for the same shoulder procedure episode, we considered that for a patient with two different register hits indicating a shoulder capsular surgery procedure within two months this would be the same procedure and treatment episode. (II, III)

For Study IV, we conducted a retrospective medical record review to identify patients operated on with arthroscopic LR for shoulder instability at Töölö Hospital, Helsinki University Hospital, Helsinki, Finland between January 1994 and December 1998. As inclusion criteria, we required a traumatic primary shoulder dislocation, no previous operations in the index shoulder region, and a labrum lesion as an intraoperative finding. All patients gave informed consent.

We assessed clinically and radiologically 72 patients (74 shoulders) (71%) of the initial potentially suitable 101 patients with a mean follow-up time after the index shoulder surgery procedure of 13 years (range 11-15). One-third of patients were operated on after a primary traumatic shoulder dislocation. We additionally interviewed by telephone nine patients who were unable to attend the arranged follow-up visit. We were unable to retrieve a mailing address for six patients and could not reach eight patients regardless of numerous attempts. Three patients lived abroad, and another three declined participation in the study. We present the demographics of examined and interviewed patients in Table 4. (IV)

Table 4. *Patient characteristics of 81 individuals (83 shoulders)* with a mean follow-up of 13 years after arthroscopic labrum repair.*

Patients	81
Male	60
Female	21
Number of operated shoulders	83
Age at time of initial surgery (years)	29 ± 9; (range 15–59)
Number of dislocations before initial surgery	
One dislocation	28 (34%)
2-5 dislocations	20 (24%)
5-10 dislocations	10 (12%)
> 10 dislocations	25 (30%)
Delay from initial shoulder dislocation to surgery (years)	5 ± 8; (range 0-38)
Number of patients with re-operations to the index shoulder due to recurrent instability	12

Adapted from Kavaja et al. J Shoulder Elbow Surg 2012. (IV)

**72 patients (74 shoulders) were assessed clinically, two patients had a bilateral complaint and an additional nine patients were interviewed.*

4.3 SURGICAL TECHNIQUE (IV)

One senior orthopaedic surgeon performed all initial shoulder surgery procedures in Töölö Hospital between 1994 and 1998. The patient lay in the beach-chair position under general anaesthesia. A standard posterior portal and an anterior portal above the subscapularis tendon were established, and after general evaluation of the glenohumeral joint, the anterior labral lesion was evaluated. The anterior capsulolabral structures were freed from the neck of the glenoid with a rasp, and a bur was used to create a raw bleeding bony surface throughout the length of the anterior labral lesion. A Suretac fixation tack (Acufex Microsurgical, Mansfield, MA, USA) was introduced over a guidewire and seated with use of a cannulated driver. The procedure was repeated with a second tack. If the whole lesion was not securely fixed with the second Suretac fixation tack, an additional one or two intra-articularly positioned tacks were used.

The operated shoulder was immobilized in a sling for a period of three weeks after the surgery, and the patients followed a rehabilitation protocol, including active-assisted ROM exercises and isometric and concentric strengthening. Limited return to sports was allowed at three months. The surgeon routinely assessed the patients postoperatively at two weeks, three months, and six months.

4.4 FOLLOW-UP (IV)

We contacted and invited the patients to attend the outpatient clinic at Töölö Hospital. The clinical examination included shoulder function and stability testing. We tested the shoulder stability with apprehension test, relocation test, and hyperlaxity with anterior and posterior load-and-shift tests and sulcus sign test. We tested shoulder ROM in elevation, abduction, ER, and IR (humerus in 90° abduction).

We objectively evaluated the function of the index shoulder with Constant Score (162), and the patient's self-evaluated shoulder OA-specific and instability-specific shoulder function by Western Ontario Osteoarthritis of the Shoulder (WOOS) (285) and WOSI questionnaires, respectively. Patients rated subjective satisfaction with surgery results with a five-point Likert scale and symptoms and inconvenience with open questions.

We took radiographs from both shoulders with anteroposterior and axillary projections. An independent radiologist performed the radiologic evaluation of glenohumeral OA by the Samilson-Prieto (S-P) classification (286), which grades glenohumeral OA by the size and presence of osteophytes, narrowed joint gap, and subchondral sclerosis (0, normal glenohumeral joint; 1, mild osteoarthritis; 2, moderate osteoarthritis; or 3, severe osteoarthritis). Examples of each pathognomonic grade (mild-severe) of glenohumeral OA according to the S-P classification are presented in Figure 3.

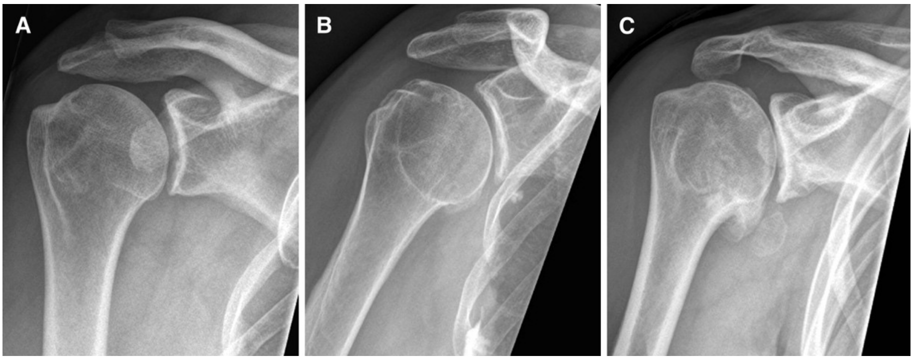

Figure 3. In the Samilson-Prieto classification, osteoarthritis is defined by the size and presence of osteophytes, narrowed joint gap, and subchondral sclerosis. (A) In mild osteoarthritis (grade 1), glenoid osteophytes are less than 3 mm in size; (B) in moderate osteoarthritis (grade 2), inferior humeral or glenoid osteophytes are 3 to 7 mm in size; and (C) in severe osteoarthritis (grade 3), osteophytes are more than 7 mm with or without articular incongruence. Reproduced with permission from Elsevier. Kavaja et al. J Shoulder Elbow Surg 2012. (IV)

4.5 ANALYSES (I, II, III, IV)

In Study I, we performed direct MA of clinically homogeneous studies (patients, indications of treatment, intervention pairs, and outcomes). If studies with the same intervention-control pairs were not generally homogeneous, we performed multiple pairwise direct MAs of the trials. In the analysis of operative treatment of a first-time shoulder dislocation, we performed a frequentist NMA to determine the effectiveness of different surgical treatment options according to suitable and matching time points available in the included studies. Since the majority of recurrent shoulder dislocations occur within two years (119, 137, 287-291), we prioritized the outcomes at that time point for the relevant assessment. Even though trials had reported outcomes at multiple time points, we included data from only one time point in a single analysis. We calculated the number needed to treat

(NNT) for statistically significant between group comparisons and intervention pairs with dichotomous outcomes (292). The NNT describes the number of patients who need to receive treatment to prevent one patient from having an event (i.e. shoulder redislocation). We calculated the NNTs in the applicable trials from the point estimates of the relative risk ratio (RR), base redislocation risk, and the redislocation rates reported in the trials. The natural course risk for a patient to suffer a subsequent dislocation after the primary episode is described by the base redislocation risk. We adopted the base redislocation risk range of 21% (pooled overall) to 47% (level I studies only) from an SR, which assessed the fundamental risk and risk factors for recurrent dislocations in level I and level II prognostic studies (12).

We anticipated variation among patients and outcome measurements, and therefore, based all analyses on random effects models and used I square statistics to quantify the statistical heterogeneity. We did not perform sensitivity analyses or meta-regression analyses to explore heterogeneity or the effect of bias. The NMA evaluated inconsistency with tau square, Cochran Q statistic, corresponding p-values, and the net heat plot and the assumption of exchangeability with qualitative analysis (293). The constructed network included a low number of trials, and therefore, we could not estimate the best treatment with the use of exchangeability assessment with quantitative methods or the use of P-score. We did not primarily plan sub-group analyses.

We used the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach to rate the quality of evidence and present a summary of findings table (294). For inconsistency, we downgraded if the magnitude or direction of effects was dissimilar, the confidence intervals (CIs) had minimal overlap, the test of heterogeneity was significant, or the I square was >50%. We downgraded for imprecision if the CIs were very wide or if the Optimal Information Size (OIS) criteria were not met. We performed the MAs with Review Manager (RevMan) (V 5.3.5) (295), and the NMA with R (V 3.2.1) (296) and the netmeta package (293) and the GRADE judgements and the summary of findings table with GRADEpro GDT (297). (I)

In Studies II and III, we calculated the surgery procedure incidences by dividing the number of procedures by the respective number of people at that year in the population. In Study II, we analysed the incidence rates (per 100,000 person-years) according to year and different age groups in the whole country and in university hospital districts. In Study III, we analysed the incidence rates (per 100,000 person-years) according to hospital type (public versus private) and different age groups.

For Studies II and III, we used Microsoft Excel 2013 software (Microsoft, Seattle, WA, USA) for the statistical analysis and Microsoft Excel 2007 software (Microsoft, Seattle, WA, USA) for Study IV. The surgery rates in Studies II and III were not sample-based estimates, but were based on the entire population of Finland, and thus, we did not calculate 95% CIs.

4.6 ETHICAL CONSIDERATIONS (I, II, III, IV)

For Studies II and III, permission to collect registry data from FHDR and from the reimbursement register of the Social Insurance Institution was covered in a previous approval from the predecessor of the National Institute of Health and Welfare and the National Research and Development Centre for Welfare and Health for the PERFECT project. (II, III) In Study IV, all potentially suitable patients were contacted by telephone after careful medical record review, and the patients were given information about the study. We gave willing patients thorough information about the study protocol and sent an informed consent form to be signed. For cooperative patients fulfilling inclusion criteria, we sent study questionnaires and invited them to clinical and radiographic examinations at Töölö Hospital, Helsinki Central Hospital, Helsinki, Finland. Participation was voluntary for all patients and they had a right to withdraw from the study at any time point without providing a reason. (IV)

Ethical approval was not required for Studies I, II and III. Study IV was approved by the Ethics Committee of the University of Helsinki (114/13/03/02/09) on 9 June 2009.

5 RESULTS

5.1 SYSTEMATIC REVIEW (I)

5.1.1 STUDY CHARACTERISTICS

After duplicate removal, the literature search yielded 2867 reports. Of these reports, we considered 55 for inclusion after review of titles and abstracts and included 25 publications (22 RCTs) after full text review. We present the study accrual in Figure 4.

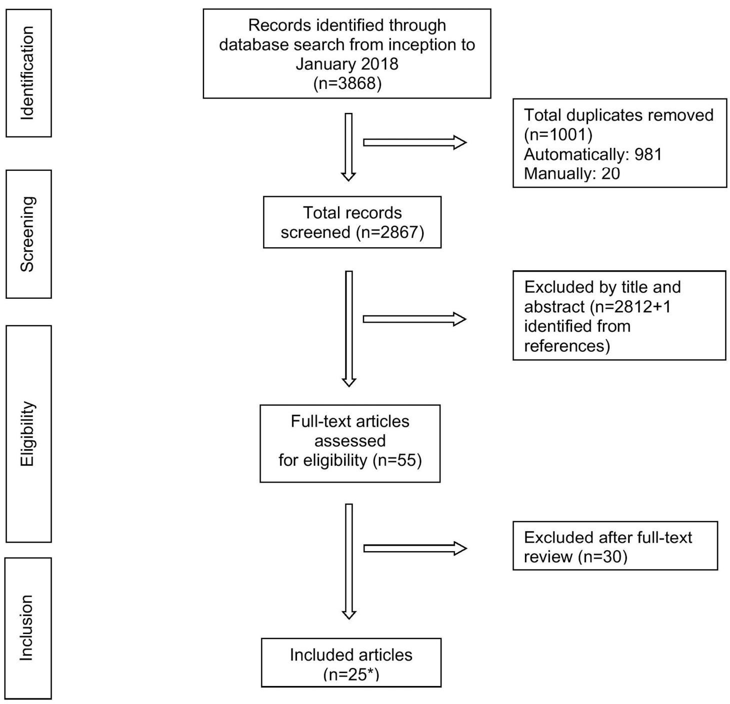

Figure 4. Study accrual flow chart. Adapted from Kavaja et al. Br J Sports Med 2018. (I)
*25 publications from 22 RCTs

Treatment after a primary traumatic shoulder dislocation was investigated in 10 out of the 22 included RCTs. In four studies, the study question was whether surgery was advantageous after a primary traumatic shoulder dislocation (22, 48, 50, 181, 205, 206), in five RCTs the effect of upper extremity immobilization in ER versus IR in preventing further shoulder instability was evaluated (46, 47, 52, 250, 251), and in one publication a combination of use of a motion restriction band after immobilization in ER versus immobilization in ER only was examined (270). Twelve RCTs concentrated on chronic post-traumatic instability. Of these, four RCTs compared open and arthroscopic LR (49, 264, 265, 267), three compared absorbable and non-absorbable suture anchors (198, 199, 218), and five were in separate individual categories because of non-comparable study questions (51, 217, 266, 268, 269, 271).

We identified six unpublished RCTs, which are presented in Appendix Table 1. Despite efforts, we failed to receive data from these unpublished trials, and therefore, we could not include the data in our analyses. We identified 20 ongoing RCTs, which were potentially within the scope of our SR. We present the ongoing RCTs in Appendix Table 2.

Patients' average age ranged between 20.3 and 36 years. The range in the mean follow-up time between studies was from 12 to 143 months. The mechanism of injury was not reported in seven RCTs (51, 52, 199, 264-267), but in 15 RCTs 67% of the first-time shoulder dislocations were due to traumatic origin in sporting activities. Only one study included patients with large bony defects of the glenoid (51). We present the trial summary in Table 5.

Table 5. *Summary of the included RCTs.*

Author, year	Intervention	Control	N: recruited/FU	Follow-up time	Mean age of patients	Main outcome (primary outcome if defined)
First-time traumatic dislocation						
Early surgery						
Kirkley et al. (I) 1999[22], (II) 2005[48]	Arthroscopic LR	3 weeks immobilization	**(I)** 40/38 **(II)** 40/31	**(I)** I: 31.7 (18.1-51.1) C: 33.1 (21.8-54.2) **(II)** 79 (51-102)	I: 22.1 C: 22.75	**(I)** RDR: I: 3/19 (16%) - C: 9/19 (47%) p=0.03 **(II)** Mean WOSI (%): I: 86% - C: 74.8%, NS
Wintzell et al. (I) 1999[298], (II) 1999[206]	Arthroscopic lavage	1 week sling	**(I)** 57/60 **(II)** 30/30	**(I)** 1 year **(II)** 2 years	**(I)** I: 23.5 (±3.8) C: 23.6 (±3.8) **(II)** Total: 24 years	**(I)** RDR: I: 4/30 (13%) - C: 13/30 (43%), p=0.02 **(II)** RDR: I: 3/15 (20%) - C: 9/15 (60%) - p=0.03
Jakobsen et al. 2007[181]	DA and open LR	Arthroscopic lavage	76/75	2 years 10 years	I: 23 (15-39) C: 20 (15-31)	RDR 2 years: I: 1/37 (3%) - C: 21/39 (54%), p=0.0011 RDR 10 years I: 3/36 (9%) - C: 24/39 (62%) p NR
Robinson et al. 2008[299]	Arthroscopic LR	Arthroscopic lavage	88/84	2 years	I: 24.3 (±4.6) C: 25.3 (±4.8)	RDR: I: 3/42 (7%) - C: 12/42 (38%), p=0.02
Arm position						
Itoi et al. 2007[250]	ERI 3 weeks	IRI 3 weeks	198/159	25.6 (24-30)	I: 35 (12-90) C: 37 (12-89)	RIR: I: 22/85 (26%) - C: 31/74 (42%), p=0.033
Finestone et al. 2009[251]	ERI 4 weeks	IRI 4 weeks	51/51	I: 35.8 (24-48) C: 30.8 (24-47)	20.3	RDR: I: 10/27 (37%) - C: 10/24 (42%), NS
Liavaag et al. 2011[300]	ERI 3 weeks	IRI 3 weeks	188/183	29.1 (24-54)	26.8 (15.9-40, ±7.1)	RDR: I: 28/91 (31%) - C: 23/93 (25%), NS RIR: I: 31/81 (38%) - C: 36/82 (42%), NS
Heidari et al. 2014[46]	ERI 3 weeks	IRI 3 weeks	102/102	24	I: 36 (±7.8) C: 35.43 (±10.0)	RIR: I: 2/51 (3.9%) - C: 17/51 (33.3%), p<0.001
Whelan et al. 2014[52]	ERI 4 weeks	IRI 4 weeks.	60/50	25 (12-43)	I: 23 (16-35) C: 23 (14-34)	RDR: I: 6/27 (22%) - C: 8/25 (32%), NS
Use of restriction band						
Itoi et al. 2013[270]	C + I1: MRB 3 or I2: MRB 6 wks	ERI 3 weeks	109/90	I1: 26.5, I2: 26.5 C: 25.5	30 (15-84)	RDR: I1: 10/31 (32%) - I2: 10/30 (33%) - C: 8/29 (28%), NS
Chronic post-traumatic shoulder instability						
Open or arthroscopic surgery						
Sperber et al. 2001[301]	Arthroscopic LR	Open LR	56/56	24	I: 25 (18-51) C: 27.5 (19-45)	RIR: I: 7/30 (23%) - Control: 3/26 (12%), NS
Fabbriciani et al. 2004[265]	Arthroscopic LR	DA and open LR	60/60	24	I: 24.5 (19-33) C: 26.8 (21-30)	CS (SD) [difference from BL (SD)]: I: 89.5 (±4.25) [23 (±5.89)] points - C: 86.7 (±6.07) [20.2 (±8.22)] points, NS

Netto et al. 2012[264]	Arthroscopic LR	Open LR	50/42	37.5 (20-56)	I: 27.5 (±5.4) C: 30.8 (±5.6)	DASH (range, SD): I: 2.65 (0-24, ±7.3) - C: 4.22 (0 to 21, ±5.8), p=0.031 (note: MCID is >10) [302]
Mohtadi et al. 2014[303]	Open LR	Arthroscopic LR	196/162	24	I: 27.8 (16-53.7, ±7.9) C: 27.2 (16.5-59, ± 9)	WOSI (95% CI) BL -> FU: I: 41.7% (37.9-45.5) -> 85.2% (80.5-89.8) **-** C: 40.6% (36.9-44.3) -> 81.9% (77.4-86.4), NS
Absorbable or non-absorbable implant materials (anchors)						
Warme et al. 1999[199]	Open LR, non-A SA	Open LR, bio-A SA	38/40	25 (17-45)	22 (17-46)	Loss of ER (degrees): I: 3 (0-15) - C: 3 (0-10), NS
Tan et al. 2006[202]	Arthroscopic LR, non-A SA	Arthroscopic LR, bio-A SA	124/124	2.6 (1.5-5) years	I: 27 (18-45, ±7) C: 28 (17-49, ±8)	OSIS (SD): BL -> FU: I: 36 (±8) -> 18 (±6) - C: 36 (±7) -> 20 (±10), p not reported
Milano et al. 2010[198]	Arthroscopic LR, non-A SA	Arthroscopic LR, bio-A SA	78/70	24.5 (22-29)	I: 28 (16-46) C: 28 (16-52)	DASH (range): I: 4.5 (0-27) - C: 7 (0-25), NS
Addition of posterior capsular plication						
Castagna et al. 2009[266]	Arthroscopic LR, bio-A SA	I + posterior capsular plication	40/40	2 years	I: 29.1 C: 27.3	FF BL -> FU: I: 169 (83-105) -> 172.5 (155-180) - C: 177.8 (170-180) -> 163.3 (140-175) p for change <0.001
Different absorbable implant materials						
(I) Magnusson et al. 2006[268] (II) Elmlund et al. 2009[269]	Arthroscopic LR PLLA tacks	Arthroscopic LR PGACP tacks	40/35	**(I)** I: 25 (24-34) C: 26 (23-35) **(II)** I: 80 (75-95) C: 81 (64-96)	I: 26 (16-50) C: 30 (15-45)	**(I)** Drill hole visibility: More visible in I, p<0.004 **(II)** Drill hole visibility: More visible in I, p<0.0001
Absorbable or non-absorbable suture materials						
Monteiro et al. 2008[217]	Arthroscopic LR bio-A SA + bio-A sutures	Arthroscopic LR bio-A SA + non-A sutures	50/45	I: 31.47 (24-45) C: 30.85 (24-45)	23.5 (16-37)	Rowe (range): I: 83.81 (35-100) - C: 79.58 (35 to 100), NS
Rehabilitation						
Kim et al. 2003[304]	Accelerated	Traditional	62/62	31 (27-45, ±9)	I: 29 (15-38, ±5.8) C: 28 (18-39, ±5.6)	RDR: 0/62 (0%), Subluxation rate: 0/62 (0%), NS
Anatomic versus non-anatomic surgery						
Salomonsson et al. 2009[51]	Open LR and capsular imbrication	Modified PP procedure	66 / 62	143 (121-162, ±12.2)	I: 29 (17-52) C: 26 (16-63)	Rowe: I: 90 - C: 90, NS

Follow-up times are tabulated as presented in the original publication as mean (range) in months, unless noted otherwise. Mean age is presented as mean (range) or mean (±SD) or mean (range ±SD) in years, unless noted otherwise. Bio-A: Bioabsorbable; BL: Baseline; CI: Confidence interval; CS: Constant score; C: Control; DASH: Disabilities of the Arm, Shoulder, and Hand; FU: Follow-up; FF: Forward flexion (in degrees); ERI: External rotation immobilization; IRI: Internal rotation immobilization; I: Intervention; MRB: Motion restriction band; Non-A: Non-absorbable; NR: Not reported; NS: No statistically significant difference; OISS: Oxford Instability Shoulder Score; PP: Putti Platt; RDR: Redislocation rate; RIR: Recurrent instability rate; SD: Standard deviation; SA: Suture anchor; WOSI: Western Ontario Shoulder Instability Index Score. Adapted from Kavaja et al. Br J Sports Med 2018. (I)

5.1.2 QUALITY OF INCLUDED TRIALS AND RISK OF BIAS

Of all studies, 21 were classical RCTs; one used a minimization algorithm (50), and all trials included analogous patient groups. Two trials were double-blind (50, 218), seven trials were single-blind (22, 48, 52, 198, 217, 266, 268, 269, 271), and 13 trials were not blinded (46, 47, 49, 51, 181, 199, 205, 206, 250, 251, 264, 265, 267, 270). Fourteen trials described sample size estimation (22, 46-52, 198, 250, 251, 264, 268-271), only one of which met the attempted estimation of sample size (46). All trials reported ITT analysis. Marked variation existed in the number of patients in the trials, as the sample size ranged from 30 to 198 participants. Among the trials, the patient drop-out rate ranged from 0% to 20%.

We considered the risk of bias high in two RCTs due to variation in the timing of the follow-up assessments (199, 251); in three (14%) of the 22 trials the scheduled and carried out follow-up visits were reported unambiguously to meet the accepted deviation of less than three months (47, 198, 250). We present the complete risk of bias assessment of the included trials in Appendix Table 3.

Two studies disclosed a potential COI and industrial sponsorship (269, 270), three trials (199, 217, 250) reported a sponsorship, and another five trials (22, 51, 181, 264, 268) reported either a sponsorship or COI. Six RCTs made an explicit statement of not having interfering COIs or sponsorships (46, 47, 49, 50, 52, 251), while nine studies did not provide a statement about

COI or possible sponsorship (Appendix Table 3) (48, 198, 205, 206, 218, 265-267, 271).

5.1.3 GRADE JUDGEMENT AND SUMMARY OF FINDINGS

The quality of the evidence in the RCTs varied from very low to moderate. We downgraded most commonly because of imprecision and absence of blinding. The GRADE summary of findings table is presented below each subsection of the synthesis of results.

5.1.4 SYNTHESIS OF RESULTS

5.1.4.1 First-time traumatic shoulder dislocation

5.1.4.1.1 Early surgery

In the NMA, we compared LR, NSM, and AL of the glenohumeral joint in reducing shoulder redislocations at the one- and two-year time points. The NMA included four studies at both one- (22, 50, 181, 205) and two-year (22, 50, 181, 206) time points with 273 and 243 patients, respectively. The calculated RR at one year between LR and NSM was 0.08 (95% CI 0.02 to 0.27, P<0.001). RR in the comparison of LR versus AL was 0.23 (95% CI 0.08 to 0.67, P=0.007, I square=0%, P=0.46). At the two-year time point, RR in the comparison between LR and NSM was 0.15 (95% CI 0.03 to 0.8, P=0.026) and in the comparison between LR and AL 0.21 (95% CI 0.05 to 0.91, P=0.037, I square=63.6%, P=0.064). The NMA analyses at the one- and two-year time points and the summary of findings are presented in Figures

5A and 5B and Table 6, respectively. There was a benefit of AL at one year compared with NSM, as the RR was 0.34 (95% CI 0.14 to 0.86, P=0.023) (Figure 5A); however, this benefit vanished at the two-year time point (RR 0.71; 95% CI 0.14 to 3.68, P=0.686) (Figure 5B). We were able to perform a direct MA only between studies comparing LR and AL. This comparison included two studies (160 patients) (50, 181) and showed a favourable treatment effect of LR (RR 0.13; 95% CI 0.03 to 0.69, P=0.02, I square=54%, P=0.14) (Appendix Figure 1). The NNT to prevent a redislocation at two years ranged from 2.0 to 4.7 using the redislocation rates in the included RCTs (22, 50, 181) and between 2.5 and 5.6 according to the base risk obtained from the previously mentioned SR (12).

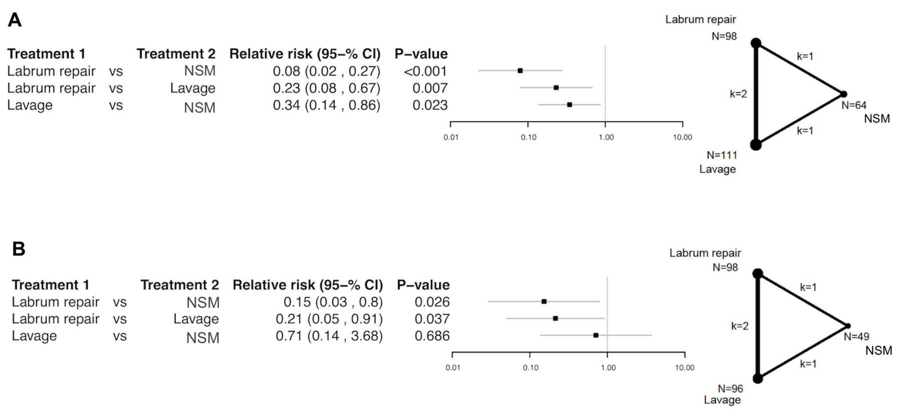

Figure 5. Relative risk of a redislocation after treatment of a first-time traumatic shoulder dislocation at (A) 1 year and at (B) 2 years, derived from the network meta-analysis. CI: Confidence interval; NSM: Non-surgical management. Adapted from Kavaja et al. Br J Sports Med 2018. (I)

Table 6. *Labrum repair compared with physiotherapy for prevention of recurrent dislocations after a first-time traumatic shoulder dislocation.*

Patient or population: A first-time traumatic shoulder dislocation
Setting: Surgery versus non-surgical management
Intervention: Labrum repair
Comparison: Physiotherapy

Outcome No. of patients (studies)	Relative effect (95% CI)	Anticipated absolute effects (95% CI)			Certainty	What happens
		Non-surgical	Labrum repair	Difference		
Redislocation rate after surgery **FU (mean): 2 years** **No. of patients 243 (4 RCTs)**	RR 0.15 (0.03 to 0.8)	52.9%	7.9% (1.5 to 42.3)	45% fewer (51.4 fewer to 10.6 fewer)	⊕⊕⊕◯ MODERATE*	Labrum repair may be beneficial in reducing the rate of redislocations

CI: Confidence interval; FU: Follow-up; RCT: Randomized controlled trial; RR: Relative risk. Adapted from Kavaja et al. Br J Sports Med 2018. (I)
**Rated down for serious risk of bias (lack of blinding) and serious imprecision. Rated up for large magnitude of an effect.*

5.1.4.1.2 Arm position

A great deal of heterogeneity was present between the studies comparing arm position, and therefore, we performed three separate direct comparison MAs in studies sufficiently homogeneous to compare immobilization in ER versus IR: one of the trials with young patients and a narrow age range reporting shoulder redislocations, the second of a subset of the former reporting symptomatic shoulder instability, and the third of older patients with a wide age range reporting symptomatic shoulder instability. Arm position did not have an impact on outcome in any of the comparisons. In the comparison of three trials (287 patients) (47, 52, 251) reporting redislocations in patients with a narrow age range and an average age of 25 years, the RR was 1.07 (95% CI 0.76 to 1.50; P=0.70; I square=0%; P=0.65) (Appendix Figure 2A). Two of these trials (236 patients) (47, 52) also reported symptomatic instability, and therefore, we carried out an additional direct MA (RR 1.01; 95% CI 0.82 to 1.24; P=0.90; I square=0%; P=0.78) (Appendix Figure 2B). Two other trials (261 patients) (46, 250) included significantly older patients (average age 35 years) with a wide age range and reported only symptomatic shoulder instability. In the direct MA between these studies, the RR was 0.31 (95% CI 0.06 to 1.68; P=0.17; I square=82%; P=0.02) (Appendix Figure 2C). The summary of findings is presented in Table 7.

Table 7. *Immobilization in external rotation compared with internal rotation for prevention of recurrent shoulder dislocations or chronic post-traumatic shoulder instability after a first-time traumatic shoulder dislocation.*

Patient or population: A first-time traumatic shoulder dislocation
Setting: Non-surgical versus non-surgical management
Intervention: Immobilization in ER
Comparison: Immobilization in IR

Outcome No. of patients (studies)	Relative effect (95% CI)	Anticipated absolute effects (95% CI)			Certainty	What happens
		IR	ER	Difference		
Recurrent instability rate after immobilization in older population FU (mean): 2 years No. of patients 261 (2 RCTs)	RR 0.31 (0.06 to 1.68)	38.4%	11.9% (2.3 to 64.5)	26.5% fewer (36.1 fewer to 26.1 more)	⊕◯◯◯ VERY LOW*	Immobilization in external rotation does not seem to be beneficial in prevention of shoulder instability
Redislocation rate after immobilization in younger population FU (mean): 2 years No. of patients 287 (3 RCTs)	RR 1.07 (0.76 to 1.50)	30.3%	32.4% (23.0 to 45.4)	2.1% more (7.3 fewer to 15.1 more)	⊕⊕◯◯ LOW **	Immobilization in external rotation does not seem to be beneficial in prevention of shoulder redislocations

CI: Confidence interval; ER: External rotation; FU: Follow-up; IR: Internal rotation; RCT: Randomised controlled trial; RR: Relative risk. Adapted from Kavaja et al. Br J Sports Med 2018. (I)

**Rated down for serious risk of bias (lack of blinding), serious inconsistency, and strongly suspected publication bias.*

***Rated down for serious risk of bias (lack of blinding) and strongly suspected publication bias.*

5.1.4.1.3 Restriction band usage

Immobilization in ER followed by use of a shoulder motion restriction band (versus immobilization in ER only) did not have an effect on shoulder redislocation rates (270).

5.1.4.2 Chronic post-traumatic shoulder instability

5.1.4.2.1 Open versus arthroscopic surgery

In a direct MA between three studies (269 patients) (49, 264, 265), open LR prevented recurrent dislocations with a statistically significant difference (RR 0.43; 95% CI 0.19 to 0.97; P=0.04; I square=0%; P=0.43). Open LR prevented also recurrent symptomatic instability with a statistically significant difference in a direct MA between two studies (223 patients) (49, 267) (RR 0.49; 95% CI 0.26 to 0.92; P=0.03; I square=0%; P=0.99). (Appendix Figures 3A and 3B). We present the summary of findings in Table 8.

Table 8. *Summary of findings for open versus arthroscopic labrum surgery to treat chronic post-traumatic shoulder instability.*

<table>
<tr><td colspan="7">Patient or population: Chronic post-traumatic shoulder instability
Setting: Surgery versus surgery
Intervention: Open labrum surgery
Comparison: Arthroscopic labrum surgery</td></tr>
<tr><td rowspan="2">Outcome
No. of patients (studies)</td><td rowspan="2">Relative effect (95% CI)</td><td colspan="3">Anticipated absolute effects (95% CI)</td><td>Certainty</td><td rowspan="2">What happens</td></tr>
<tr><td>Arthroscopic</td><td>Open</td><td>Difference</td><td></td></tr>
<tr><td>Redislocation rate after surgery
FU (mean): 2 years
No. of patients 269 (3 RCTs)</td><td>RR 0.43 (0.19 to 0.97)</td><td>13.4%</td><td>5.8% (2.6 to 13.0)</td><td>7.7% fewer (10.9 fewer to 0.4 fewer)</td><td>⊕⊕◯◯
LOW*</td><td>Open labrum repair seems to be beneficial in prevention of shoulder redislocations</td></tr>
</table>

CI: Confidence interval; FU: Follow-up; RCT: Randomised controlled trial; RR: Relative risk. Adapted from Kavaja et al. Br J Sports Med 2018. (I)

**Rated down for serious risk of bias (lack of blinding) and serious imprecision.*

5.1.4.2.2 Absorbable versus non-absorbable suture anchors, tacks, or suture materials

A direct MA did not show a statistically significant difference in recurrent instability rates between absorbable and non-absorbable suture anchors in a direct MA between three studies (232 patients) (198, 199, 218) (RR 0.62; 95% CI 0.21 to 1.86; P=0.40; I square=0%; P=0.95) (Appendix Figure 4). Neither absorbability of implants nor suture material had an effect on redislocation rates (198, 199, 217, 218, 268, 269). The summary of findings is presented in Table 9.

Table 9. *Summary of findings for use of absorbable versus non-absorbable implant materials in labrum surgery to treat chronic post-traumatic shoulder instability.*

Patient or population: Chronic post-traumatic shoulder instability **Setting**: Surgery versus surgery **Intervention**: Absorbable implant material **Comparison**: Non-absorbable implant material						
Outcome No. of patients (studies)	**Relative effect (95% CI)**	**Anticipated absolute effects (95% CI)**			**Certainty**	**What happens**
		Non-absorbable	**Absorbable**	**Difference**		
Recurrent instability rate after surgery FU (mean): 2 years No. of patients 232 (3 RCTs)	RR 0.62 (0.21 to 1.86)	9.6%	5.9% (2.0 to 17.8)	3.6% fewer (7.6 fewer to 8.2 more)	⊕⊕⊕◯ MODERATE*	Absorbability of implants does not seem to affect the recurrent instability rate

CI: Confidence interval; FU: Follow-up; RCT: Randomised controlled trial; RR: Relative risk. Adapted from Kavaja et al. Br J Sports Med 2018. (I)
**Rated down for serious risk of bias (lack of blinding).*

5.1.4.2.3 Accelerated versus traditional post-operative rehabilitation and different surgical procedures

We could not perform MAs on three RCTs, all of which had a single study question in their own category (pace of rehabilitation after a surgical intervention, two trials comparing two surgical methods) (51, 266, 271). The trials did not observe any between-group differences in shoulder redislocation rates.

5.1.5 ADVERSE EFFECTS IN INCLUDED RCTS

Adverse effects were scarcely and heterogeneously reported, and therefore, we could not perform additional analyses. Three studies specified and reported adverse effects as a study outcome a priori (47, 50, 264). Thirteen studies reported adverse effects encountered, although these were not listed as a study outcome (22, 46, 49, 181, 205, 218, 250, 251, 265-269). Nine studies did not mention adverse effects (48, 51, 52, 198, 199, 206, 217, 270, 271). In the included RCTs, there were altogether 19 patients (1.5%) with temporary pain, rigidity, or stiffness in the injured shoulder, 17 patients (1.3%) with transient nerve injuries, 5 patients (0.39%) with superficial wound infections, 3 patients (0.24%) with adhesive capsulitis, and 1 patient (0.08%) with septic arthritis in the shoulder. When only non-surgically treated patients were studied, transient pain or rigidity was observed in 14 patients (3.2%), transient nerve injuries in 12 patients (2.7%), adhesive capsulitis in 1 patient (0.2%), and transient axillary rash in 2 patients (0.5%).

5.2 SHOULDER CAPSULAR SURGERY TRENDS IN FINLAND (II, III)

In Finland, a total of 13,673 shoulder capsular surgery procedures were performed between 1999 and 2008; of these, 7491 (55%) were performed in private hospitals. The annual growth in the incidence rates was on average 7% (range -3% to 18%). Annually, the proportion of procedures performed in private hospitals varied between 51% and 59%. The annual incidence rates increased in public and private hospitals 6% and 9%, respectively. The average annual incidence of shoulder capsular surgery procedures was 26 (range 17-33) per 100,000 person-years, and between the years 1999 and 2007 the incidence rates increased by 88%. The year 2007 was used in the comparison, with the peak in annual procedures reached this year. We present the essential details of the patient material in Table 10.

Table 10. *Key descriptors among 13,673 patients operated on for shoulder capsular lesions in Finland between 1999 and 2008.*

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Procedures*	892	1009	1195	1299	1306	1450	1543	1587	1722	1670
Procedure incidence**	17.3	19.6	23.1	25.1	25.1	27.8	29.5	30.2	32.7	31.5
Arthroscopy (%)	63.2	72.7	78.3	81.0	83.1	88.1	89.4	91.9	92.9	91.7
Age (mean, years)	38.7	37.0	37.9	38.3	37.5	36.6	36.1	35.3	35.7	35.0
Male (%)	69.8	69.8	69.3	69.6	70.5	69.7	70.8	70.0	67.8	70.1
Procedures in UH (%)	19.1	22.3	17.2	15.9	17.2	16.2	22.2	19.1	22.6	17.4

UH: University hospital. Adapted from Kavaja et al. Scand J Surg 2018. (II, III)
**NBE20, NBE25, NBE30, NBE35, NBE40 and NBE45*
***Per 100,000 person-years*

5.2.1 THE WHOLE COUNTRY (II)

Of the total average annual incidence, the arthroscopic surgery procedure was performed in 22 (range 11-30) (85%) of the 26 procedures per 100,000 person-years. The annual incidence of arthroscopic procedures increased on average 12% (range -5% to 30%). The incidence of arthroscopic procedures increased by 89% between 1999 and 2007, and the proportion of arthroscopic procedures increased from 63% to 93% (Table 10). The incidence of arthroscopic procedures decreased slightly from 30 in 2007 to 29 in 2008 per 100,000 person-years. We present the annual incidences of shoulder capsular surgery procedures per 100,000 person-years between 1999 and 2008 in Figure 6.

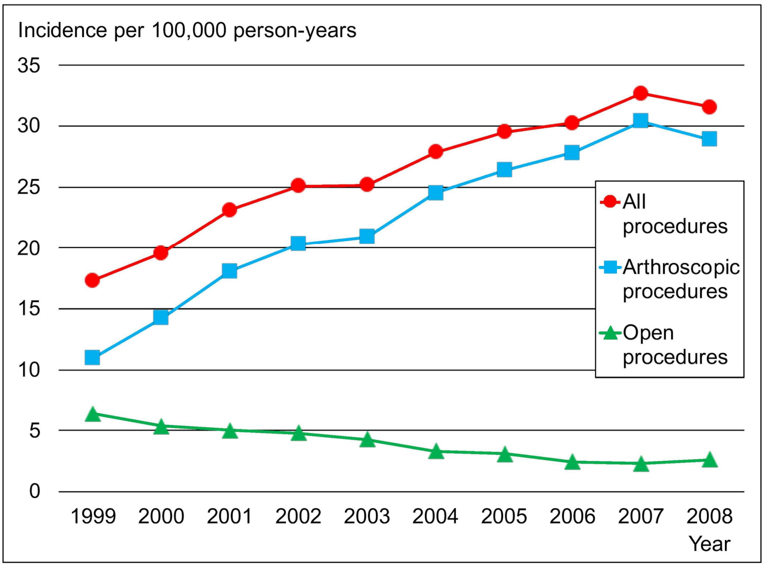

Figure 6. Incidence of shoulder capsular surgery procedures in Finland between 1999 and 2008 per 100,000 person-years. Adapted from Kavaja et al. Scand J Surg 2018. (II)

The average annual incidence of open shoulder capsular surgery procedures was 4 (range 2-6) per 100,000 person-years and the annual decrease was on average 9% (range -22% to 13%). In total, the incidence of open shoulder capsular surgery procedures decreased by 64% between 1999 and 2007.

5.2.2 AGE GROUPS (II)

The highest average annual incidence was 66 (range 37-86) per 100,000 person-years in the age group 21-30 years, whereas the lowest average annual incidence of 11 (range 6-15) per 100,000 person-years was observed in the age group over 61 years. The incidence rates increased on average by 89% (range -37% to 200%) in all age groups between 1999 and 2007, but the most distinct growth was observed in patients aged between 41 and 50 years.

The only decrease in the incidence rates was observed in patients over 61 years. We present the shoulder capsular surgery incidence rates in different age groups in Figure 7.

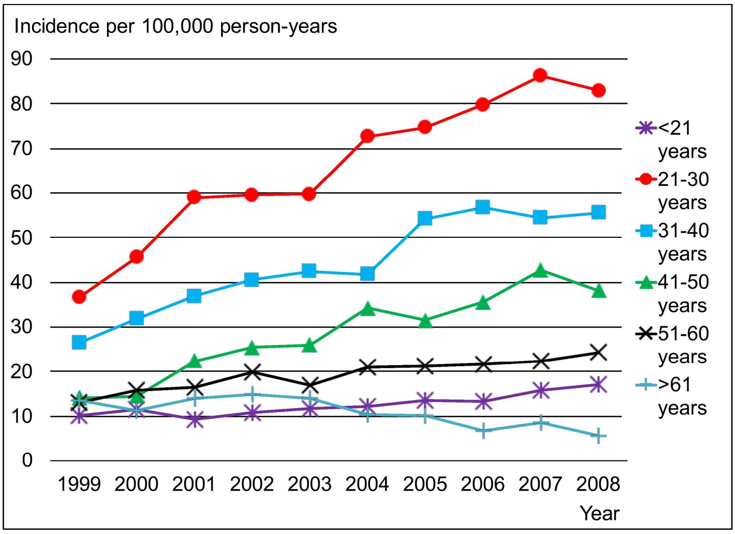

Figure 7. Incidence of shoulder capsular surgery procedures in age groups in Finland between 1999 and 2008 per 100,000 person-years. Adapted from Kavaja et al. Scand J Surg 2018. (II)

The highest average annual incidence of arthroscopic procedures of 59 (range 25-82) per 100,000 person-years was observed in patients aged between 21 and 30 years, whereas in patients over 61 years of age the average annual incidence rate was the lowest at 6 (range 4-8) per 100,000 person-years. The incidence of arthroscopic shoulder capsular surgery procedures increased between 1999 and 2008 on average by 160% (range -12% to 280%) in all age groups, excluding only the patients over 61 years of age; the greatest increase was observed in patients aged between 41 and 50 years.

In patients between 21 and 30 years, the average annual incidence of open procedures was 7 (range 4-12) per 100,000 person-years, which was the highest observed annual incidence rate. In patients under 21 years of age, we observed the lowest incidence rate of 1 (range 0.5-3) per 100,000 person-years. The annual incidence of open procedures decreased between 1999 and 2008 on average by 55% (range 24% to 80%) in all age groups; the most distinct drop was observed in patients over 61 years of age.

5.2.3 UNIVERSITY HOSPITAL DISTRICTS (II)

In all university hospital districts, the average annual incidence of total and arthroscopic shoulder capsular surgery procedures increased between 1999 and 2007 by 94% (range 66% to 120%) and 210% (range 110% to 310%), respectively. The average annual incidence of open procedures in all university hospital districts decreased by 63% (range 48% to 69%). We observed the clearest rising trend in the incidence rates between 1999 and 2007 in the university hospital district of Turku, but in other hospital districts the incidence rate trends were somewhat similar. We observed a particular geographical variation in the incidence rates between university hospital districts of Turku and Oulu in 2007 of 96%. We present the geographic variation of annual incidence rates in university hospital districts per 100,000 person-years between 1999 and 2008 in Figure 8.

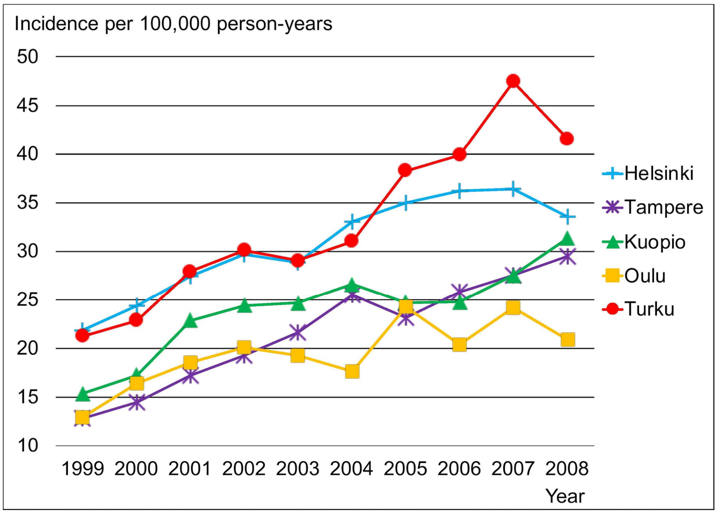

Figure 8. Geographic variation in incidence of shoulder capsular surgery procedures in university hospital districts in Finland between 1999 and 2008 per 100,000 person-years. Adapted from Kavaja et al. Scand J Surg 2018. (II)

5.2.4 EFFECT OF CHANGE IN THE REIMBURSEMENT SYSTEM (III)

5.2.4.1 Effect of change in the whole country

The overall incidence of shoulder capsular surgery procedures continued to increase with a similar trend after the change in the reimbursement system in 2005. When publicly and privately funded hospitals were observed separately from 2005 to 2008, the incidence rates increased by 20% in privately funded hospitals and decreased by 7% in publicly funded hospitals. The trend of incidence rates in the privately funded hospitals remained the same throughout the followed year-cohorts, and no distinct increase was observed after the change in the reimbursement system. The annual incidence rates increased in publicly and privately funded hospitals by 60% (annual range -6% to 14%) and 100% (annual range -7% to 37%), respectively, during the followed year-cohorts from 1999 to 2008. We present the annual incidence rates in publicly and privately funded hospitals and as a reference the total incidence rate in the whole country between 1999 and 2008 in Figure 9.

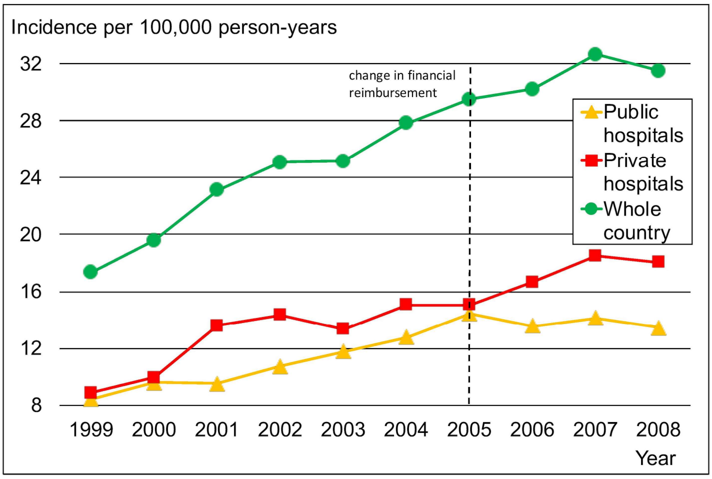

Figure 9. Incidence of shoulder capsular surgery procedures in total and in publicly and privately funded hospitals in Finland between 1999 and 2008 per 100,000 person-years. Adapted from the submitted manuscript by Kavaja et al. (III)

5.2.4.2 Effect of change in age groups

The incidence rate of shoulder capsular surgery procedures decreased in publicly funded hospitals after the change in the reimbursement system by 21% (range 2% to 26%) in patients under 41 and over 61 years of age. Simultaneously, in patients aged between 40 and 60 years the incidence increased on average by 16% (range 4% to 29%).

After the change in the reimbursement system in privately funded hospitals, the incidence rates increased in patients under 61 years of age on average by 28% (range 2% to 64%). We present the annual incidence rates in age groups in publicly and privately funded hospitals in Figures 10A and 10B, respectively.

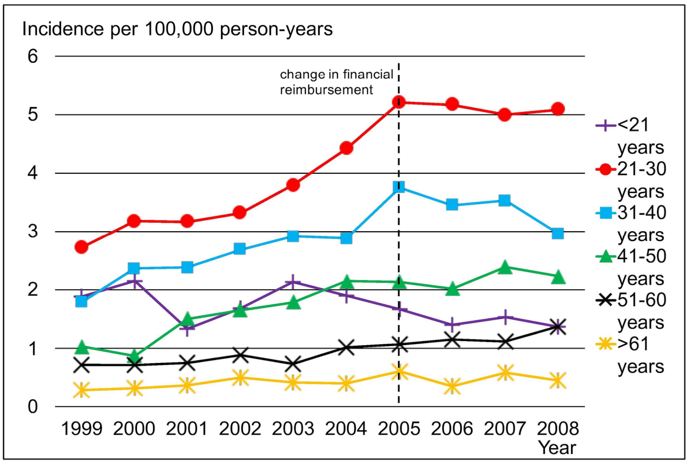

Figure 10A. Incidence of shoulder capsular surgery procedures in age groups in publicly funded hospitals in Finland between 1999 and 2008 per 100,000 person-years. Adapted from the submitted manuscript by Kavaja et al. (III)

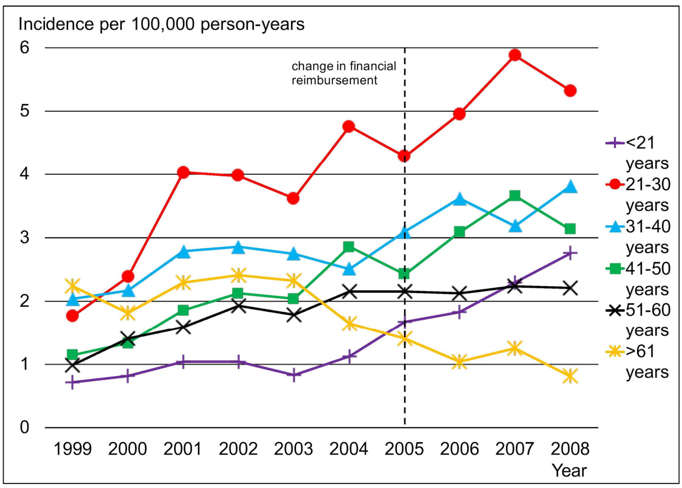

Figure 10B. Incidence of shoulder capsular surgery procedures in age groups in privately funded hospitals in Finland between 1999 and 2008 per 100,000 person-years. Adapted from the submitted manuscript by Kavaja et al. (III)

5.3 LONG-TERM SHOULDER FUNCTION AND GLENOHUMERAL OSTEOARTHRITIS (IV)

Of the 81 patients, 26% had suffered a recurrent shoulder dislocation. We graded 47 of 74 assessed shoulders (64%) as stable, whereas mild anterior instability was demonstrable in 36% of patients. Recurrent instability symptoms interfered with daily routines in 24 (30%) and with sports/recreation/work in 28 (35%) of the 81 patients. During the last year before the follow-up visits the index shoulder did not interfere at all in 30 (37%) out of 81 patients.

Reoperation was performed on 12 patients (15%) due to recurrent instability episodes. In ROM evaluation (degrees), forward elevation was on average 160°, abduction 150°, ER 55°, and IR 50°. We observed a clinical correlation in ER and IR ROM with the severity of OA, as the reach in ER and IR was better in patients with no OA or mild OA than in those with moderate or severe OA.

Constant Score of the assessed 72 patients was on average 78 points (range 20-94; SD 15). The mean score on the OA-specific shoulder function (WOOS) was 280 (range 14-1447; SD 307), which equates to 85% of the best possible score. The mean score of interviewed patients in WOOS was 144 (range 26-399; SD 129), which equates to 92% of the best possible score. Instability-related shoulder function (WOSI) was on average 457 (range 13-1920; SD 429), which equates to 78% of the best possible score. The score of interviewed patients in WOSI was on average 278 (range 95-824; SD 230), which equates to 87% of the best possible score. The overall satisfaction with surgery results was extremely satisfied or satisfied in 77% of patients. We present the instability-related shoulder function and patients' subjective evaluation of surgery results in Table 11.

Table 11. *Instability-related shoulder function (WOSI) and subjective satisfaction with surgery results in 81 patients (83 shoulders).*

WOSI (Mean ±SD (range))*	
Total (2100 points)	457 ± 429 (range 13-1920), [78%]
Physical symptoms (1000 points)	207 ± 198 (range 3-894), [79%]
Sports/Recreation/Work (400 Points)	105 ± 104 (range 0-354), [74%]
Lifestyle (400 points)	75 ± 84 (range 0-374), [81%]
Emotions (300 points)	68 ± 75 (range 0-298), [77%]
Subjective satisfaction with surgery results	
Extremely satisfied	38 (46%)
Satisfied	24 (29%)
Satisfied/unsatisfied	15 (18%)
Unsatisfied	5 (6%)
Extremely unsatisfied	0 (0%)

SD: Standard deviation; WOSI: Western Ontario Shoulder Instability Index. Adapted from Kavaja et al. J Shoulder Elbow Surg 2012. (IV)

**The best raw points are 0 and they can be converted into clinically more favourable form: [(2100 – raw points)/2100] x100%. In symptomless shoulder, the best score is 100%, and in the worst case 0%.*

An independent radiologist evaluated that radiological glenohumeral OA was present in 50 out of 74 shoulders (68%). However, according to the S-P classification the OA was considered mild in 80% of these 50 patients. Of the evaluated contralateral shoulders, 23% demonstrated signs of OA, 94% of which were graded as mild. The radiologist observed no signs of lytic changes of the glenoid. We present results of radiologic and clinical OA in Table 12 and patient details according to the grade of OA (S-P) in Table 13.

Table 12. *Radiological glenohumeral osteoarthritis evaluated with Samilson-Prieto classification and glenohumeral osteoarthritis-related shoulder function (WOOS)**

Radiological glenohumeral OA (S–P)	
Operated shoulder	
No OA	24 (32%)
Mild OA	40 (54%)
Moderate OA	9 (12%)
Severe OA	1 (1%)
Contralateral shoulder**	
No OA	54 (77%)
Mild OA	15 (21%)
Moderate OA	1 (1%)
WOOS* (Mean ±SD (range))**	
Total (1900 points)	280 ±307; (14-1447) [85%]
Physical symptoms (600 points)	95 ±96; (0-445) [84%]
Sports/Recreation/Work (500 points)	86 ±105; (1-460) [83%]
Lifestyle (500 point)	60 ±85; (0-421) [88%]
Emotions (300 points)	40 ±49; (0-200) [87%]

OA: Osteoarthritis; S-P: Samilson-Prieto; SD: Standard deviation; WOOS: Western Ontario Osteoarthritis of the Shoulder Score. Adapted from Kavaja et al. J Shoulder Elbow Surg 2012. (IV)

**Radiological glenohumeral OA was evaluated in 72 patients. An additional nine patients returned the WOOS questionnaire.*

***70 shoulders; in 2 patients both shoulders have been operated on within the follow-up time.*

****In the WOOS Score, the best raw points are 0 and the points can be converted into clinically more favourable form: [(1900 – raw points)/1900] x100%. In symptomless shoulder, the best score is 100%, and in the worst case 0%.*

Table 13. *Details of 72 patients (74 shoulders) between different stages of osteoarthritis.*

Grade of OA	Age*	Preoperative dislocations	Postoperative dislocations	WOOS (Mean ±SD (range))	WOSI (Mean ±SD (range))	Constant Score (Mean ±SD (range))**
Moderate and severe OA N=10	D: 32 S: 32	N(1)=3 N(≥2)=7	N(0)=6 N(1)=1 N(≥2)=3	800 ±380 (36-1601)	1100 ±530 (18-1145)	74 ±16 (35-88) [-14]
Mild OA N=40	D: 23 S: 30	N(1)=11 N(≥2)=29	N(0)=32 N(1)=0 N(≥2)=8	240 ±280 (14-1327)	400 ±370 (13-1361)	80 ±13 (26-93) [-10]
No OA N=24	D: 23 S: 27	N(1)=9 N(≥2)=15	N(0)=17 N(1)=1 N(≥2)=6	300 ±320 (47-1447)	500 ±490 (61-1920)	77 ±17 (20-93) [-14]

OA: Osteoarthritis; SD: Standard deviation; WOOS: Western Ontario Osteoarthritis of the Shoulder Score; WOSI: Western Ontario Shoulder Instability Index. Adapted from Kavaja et al. J Shoulder Elbow Surg 2012. (IV)

**At the time of initial dislocation (D); at the time of surgery (S).*

***Mean decrease in the age- and gender-standardized Constant Score compared with the score for healthy shoulders provided in brackets [ ].*

6 DISCUSSION

6.1 MAIN RESULTS

We have evidence of effectiveness of surgical management versus NSM for a first-time traumatic shoulder dislocation, and it seems that a LR leads to fewer redislocations with moderate evidence. Very low to low level of evidence indicates that immobilization in ER is not beneficial after a first-time shoulder dislocation compared with conventional immobilization in IR in prevention of subsequent recurrent dislocations. Currently, no RCTs have assessed the effectiveness of surgical management versus NSM or sham surgery in treatment of chronic post-traumatic shoulder instability, but a low level of evidence supports open LR preventing redislocations more efficiently than arthroscopic LR. (I)

The incidence of shoulder capsular surgery procedures in Finland almost doubled and the incidence of arthroscopic procedures almost tripled between 1999 and 2007, with significant geographical variation between the university hospital districts of Oulu and Turku. During the study period the proportion of arthroscopic procedures increased altogether from 63% to 92%. The incidence of shoulder capsular surgery procedures increased on average to 90% in all patients, except those over 61 years of age. (II)

The reimbursement system changed in 2005, and thereafter, the procedure incidences have decreased in public hospitals, whereas in private hospitals the incidences have continued to increase without a distinct change in the trend. In public hospitals, the incidence of procedures declined in patients under 41 years and over 61 years of age, while in private hospitals the incidence increased in all patients, except those over 61 years of age. (III)

The majority of patients developed radiologic glenohumeral OA after a primary shoulder dislocation or recurrent shoulder instability and arthroscopic LR. However, the OA was generally graded as mild and affected patients' shoulder function was equal to that of patients without radiologic OA. In general, glenohumeral OA-related shoulder function and instability-related shoulder function were only slightly impaired. (IV)

6.2 TRAUMATIC SHOULDER INSTABILITY

6.2.1 FIRST-TIME TRAUMATIC SHOULDER DISLOCATION (I, IV)

In treatment of primary traumatic shoulder dislocation, LR resulted in fewer redislocations than NSM at two years in our SR of RCTs. At the similar time point, AL did not reduce recurrent dislocations more than NSM, and therefore AL of the glenohumeral joint can be regarded as a placebo surgical treatment candidate in this context. According to our NMA, LR reduced recurrent shoulder dislocations compared with NSM. We observed a minor, but uniform and plausible reduction in the risk of recurrent instability episodes in the groups treated with LR. We were unable to pool data on disease-specific shoulder function scores due to heterogeneous reporting of results. However, some individual RCTs showed a difference in favour of LR in disease-specific shoulder function measurements (22, 50).

Conclusions in previous SRs and MAs of RCTs and quasi-RCTs have been more favourable towards surgery (14, 30) than in our SR. The difference can be attributed to our use of NMA in the analysis, strict inclusion of RCTs only, and handling of LR, AL, and NSM as separate entities. According to our study (IV) and another follow-up study (55), the prognosis for shoulder instability, instability-related shoulder function, and glenohumeral joint OA-related shoulder function is not impaired if surgery is postponed, i.e. not performed immediately after the primary shoulder dislocation, to see whether recurrent symptomatic instability episodes occur. Generally, as in a large long-term quasi-RCT (305) and in the included RCTs in our SR, about half of the patients experienced subsequent shoulder redislocations and the calculated NNTs are rather high, the current treatment policy (26) of eagerly performing surgical intervention after a primary shoulder dislocation is alarming. If watchful waiting and rehabilitation are the chosen approach instead of surgery, this would save half of the patients from unnecessary surgery and also eliminate a relatively small but real risk of serious adverse effects related to shoulder surgery under anaesthesia (248, 249). One in every 170-200 patients suffers a serious adverse effect after arthroscopic shoulder surgery (306).

Treatment of shoulder instability is a good example of shared decision-making. The patient's values and expectations must be considered when the treatment options are discussed. Particularly for the patient group that considers the estimated postoperative risk of redislocation of about 50% to be too high, the decision for surgical management must be a shared one. However, the decision must not be too heavily influenced by the surgeon's eagerness to operate. Therefore, despite the treatment method of choice, it is crucial that patients' expectations are thoroughly discussed to conclude what defines a successful intervention from both the patient's and surgeon's viewpoints (307). Even though, according to international literature, LR after primary shoulder dislocation might reduce overall treatment costs (50, 207), the cost-effectiveness analyses are not directly applicable to the Finnish health care system. Therefore, from the institution's as well as from a financial perspective, it is not known whether it might be cost-effective to treat operatively every patient after a primary shoulder dislocation, considering that it would mean unnecessary surgical intervention for half of the patients and predispose the patients to potential complications.

Our SR with NMA yielded similar results as published MAs of RCTs regarding arm position after a first-time shoulder dislocation (immobilization in ER versus IR), with the type of immobilization having no effect on the risk of redislocations or chronic shoulder instability (17, 19, 308). Therefore, according to the current evidence, immobilization in an ordinary arm sling should be preferred over the use of ER braces.

6.2.2 CHRONIC POST-TRAUMATIC SHOULDER INSTABILITY (I, IV)

In treatment of chronic post-traumatic shoulder instability, there are currently no high-quality studies that compare the effectiveness of surgery with NSM, although the reported recurrent dislocation rates have been low in the RCTs with open LR compared with arthroscopic LR (49, 264, 265, 267). There is still a lack of evidence for the effectiveness of the surgery itself. In addition, Hovelius observed the spontaneous ability of chronically unstable shoulders to stabilize over time in a subgroup of patients in a long-term follow-up of a quasi-RCT (23).

In our SR, the only feasible outcome analysis was on shoulder stability, and we observed that open LR was more efficient than arthroscopic LR in repairing an unstable shoulder. Previously published MAs, even with more relaxed inclusion criteria, have published similar results concerning shoulder stability (214, 215, 246), or have observed no difference in stability between arthroscopic and open techniques (31, 208-213). In our pooled analysis, the RR value was 0.43, which indicates that a failure (a recurrent dislocation) is over two times more likely with arthroscopic repair than with open repair. In addition, of the published RCTs, only one study assessed patients' instability-related shoulder function with WOSI score, and the authors did not observe differences between treatment groups (49). Of note, objective and patients' self-assessed shoulder function and ROM evaluation did not generally produce significant differences between treatment groups in the published RCTs (49, 264, 265, 267). (I)

The shoulder redislocation rate in Study IV was 26%, which is higher than in other mid- to long-term retrospective studies after an arthroscopic LR (55, 309-313), but also a few studies have reported even higher shoulder redislocation rates in treatment of chronic post-traumatic shoulder instability (314, 315). Our shoulder redislocation rate is also higher than with open LR and open Latarjet procedures in long-term follow-ups (>10 years) (316-322). It is noteworthy that our patients self-reported the recurrent shoulder dislocations and subluxations during the study assessment visit, and we did not confirm the reported episodes from patient archives. Therefore, the number of reported shoulder redislocations may not represent only true redislocations, instead also including patient-perceived redislocations (i.e. subluxations or other instability symptoms). Young patient age, significant bony defects, hyperlaxity, type of sport, too early return to contact sports, or poor compliance in post-operative rehabilitation have been identified as risk factors for recurrent shoulder instability after a surgical intervention (6, 104, 203, 232). As there is a certain complexity in the abundance of these risk factors, it is understandable that a reliable analysis of shoulder instability surgery is challenging, especially in the long-term. In addition, some or many of these risk factors may not have been known or failed to be identified when the primary operation was planned at the beginning of era of arthroscopic shoulder instability surgery. (IV)

6.2.3 LONG-TERM EFFECTS OF SHOULDER INSTABILITY (IV)

In the normal healthy population, the instability-related shoulder function measured with the WOSI score is 96.1% (323). Considering that the minimal clinically important difference (MCID) in the WOSI score is 10% (110), and in our patient material the WOSI score was on average 78%, the instability impaired patients' shoulder function only slightly. This finding agrees with two other long-term follow-ups reporting WOSI scores (315, 324). Even though we did observe a minor difference between the WOSI scores of patients assessed and interviewed only, the difference was not clinically relevant.

The WOOS score has not been in use in other studies evaluating instability-related radiologic OA and shoulder function in patients after arthroscopic LR. Also, the normal value in healthy shoulders and the MCID for the WOOS score are not known. Therefore, we cannot reliably interpret the effect of glenohumeral OA on patients' shoulder function. However, we can tentatively state that the WOOS scores of our assessed and interviewed patients of 85% and 92%, respectively, are fairly good.

In our patients, the WOSI and WOOS and Constant Score were conversely better in patients with mild radiologic OA than in those with no radiologic OA, however, otherwise the scores corresponded to the severity of OA. In our material, the age- and gender-standardized Constant Score was similarly impaired according to the degree of OA when compared with the Constant Score reported in the literature for healthy shoulders (325). Plath et al. reported a Constant Score of 94 in a follow-up study without an observed correlation with the severity of OA (55), which is significantly superior to our results. However, in a recent SR, the Constant Score was judged to be a poor tool for evaluating patients with OA and shoulder instability (326), therefore supporting our finding of only minor differences between patients with different grades of OA. The deficit in ER and IR seemed to correlate with the severity of OA in our study, which at least for ER corresponds to the findings of a study with an average follow-up of 8 years (311), but is not consistent with publications with longer follow-ups (55, 310). However, due to the retrospective nature of our study, the correlation between ROM deficit and degree of OA should be interpreted carefully since preoperative measurements were not available and the ROM deficit might be a secondary phenomenon due to glenohumeral OA or the surgical procedure itself.

The reported overall satisfaction with the results of arthroscopic LR was extremely satisfied or satisfied in 77% of patients in our study, which is less than in similar studies (309, 310). The main reasons for patients' dissatisfaction were loss of ROM and the obligation to avoid activities that promote instability symptoms. Habituation to avoid the movement patterns and conditions that cause instability symptoms might also be partly responsible for perceived disadvantages. The shoulder function has been generally considered good in mid-term and long-term follow-ups (55, 309-311, 313-315, 324). Considering that 36% of our patients showed mild symptoms of shoulder instability in clinical testing, and the instability-related shoulder function was only slightly impaired, we can cautiously state that the patients in our follow-up study were generally fairly asymptomatic.

The risk of glenohumeral OA is inherent with the natural course of shoulder instability. Hovelius et al. reported mild to moderate glenohumeral OA in a 10-year follow-up of a quasi-RCT after a primary traumatic shoulder dislocation (116), and the occurrence increased up to 60% in a 25-year follow-up (54). According to the recent MAs of follow-up studies, the prevalence and degree of OA after arthroscopic LR are more or less similar to those with open LR (241, 327) and coracoid transfer techniques (327). However, there are no RCTs to assess the evidence of the operative technique itself preventing or promoting the development of glenohumeral OA.

Generally, the prevalence and severity of OA in the index shoulder in our follow-up study were uniform with similar studies (55, 309), but the prevalence and severity might have been lower with the use of suture anchors (310). Contralateral shoulder OA was observed in 23%, which is distinctly higher than in a study with a reported comparison between operated and healthy control shoulders (315). In our patient material, the contralateral shoulder did not represent a "healthy" shoulder since we did not exclude contralateral shoulders with complaints, injuries, or performed surgical procedures. Hence, the prevalence of contralateral glenohumeral OA in our study may be biased. We observed that patients' age at the time of the primary dislocation episode and the primary surgical intervention seemed to correlate with the degree of OA (Table 13). Moreover, the younger the patients were at the time of primary shoulder dislocation, the lower the prevalence and the severity of glenohumeral OA. These findings are in agreement with the current literature (54, 55).

Radiological and clinical OA appear to be crucially different since radiologic findings do not seem to be associated with typical clinical symptoms of glenohumeral OA (328). In our study, the radiologic OA following shoulder dislocation was generally graded as mild, and in general degenerative changes were well tolerated by patients. These findings are commonly observed in the literature (55, 56, 309-311, 315, 317). It has been suggested that despite the high prevalence of shoulder dislocations relatively few patients develop debilitating symptomatic OA (327). The current literature does not explicitly report the prevalence of shoulder arthroplasty procedures due to post-traumatic glenohumeral OA, but the prevalence seems to be rare (317, 329). Therefore, reliable interpretation of causality cannot be made.

6.3 SHOULDER CAPSULAR SURGERY IN FINLAND (II, III)

6.3.1 SURGERY TRENDS IN FINLAND

According to our literature review, we have performed the first comprehensive long-term population-based study concerning shoulder capsular surgery rates in general and the distribution of shoulder capsular surgery procedures between publicly and privately funded hospitals at the national level. Eight previously published studies have reported nationally rather restricted register data or short-term results of shoulder capsular surgery rates (33-40). The trend of true population-level incidence of shoulder dislocations or instability complaints is unknown. Therefore, we can only speculate whether the true requirements for shoulder capsular surgery could have increased even partly due to the increased rate of shoulder dislocations.

Even though the incidences or the amounts of procedures in previously published studies are neither directly comparable nor generalizable to the national level (33-40), we have observed analogous progression in the trend of shoulder capsular surgery procedure incidence rates and the proportion of arthroscopic procedures. The reported proportion of arthroscopic procedures in our data (92%, 2008) corresponds to that in Bonazza et al. (40), but is slightly higher than previously published proportions (34, 36, 37).

In our study, 70% of the operated patients were male, with an average age of 37 years (Table 10). The proportion of male patients was in agreement with the published literature (33, 34, 36, 39, 40). The age distribution comparison is challenging since the age groups have been formed in a slightly different manner or left unreported, but we observed that the average age of our patients seems to be somewhat higher than in other reports (33, 34). In addition, the biggest proportion of surgery procedures was performed in the youngest age group of patients, i.e. those under 21 years of age, with procedures declining directly with age in subsequent age groups (36, 39, 40). However, we did observe a distinctly higher proportion in the incidence of annual procedures in the age group of 21–30 years compared with all other age groups, and patients under 21 years of age comprised the third biggest group for performed procedures. Also, the incidence of shoulder capsular surgery procedures increased rapidly and to surprisingly high proportions in patients aged between 41 and 60 years, comprising 27% of the performed arthroscopic procedures. The differently distributed procedures, the bigger proportion of procedures performed also on older patients, and the higher average age of our patients likely reflect the nationally gathered register data, but also the inclusion of publicly funded hospitals and the structure of the Finnish health care system.

The annual shoulder capsular surgery procedure rate increased in Norway by 20.8% from the year 2007 to 2009, and the incidence of shoulder capsular surgery procedures was 12 per 100,000 person-years in 2009 (33). In our material, we observed an increase in the incidence of arthroscopic shoulder capsular surgery procedures of 4% between 2006 and 2008, while between 2003 and 2005 the increase was 26%. It is hard to explain the difference between the incidences of shoulder capsular surgery procedures in Finland and Norway by only variation in the prevalence of shoulder instability between countries.

In the United States, Owens et al. reported a noteworthy geographical variation in shoulder capsular surgery procedures, and they have speculated, that the variation might represent effects of variability in orthopaedic training programmes and the number of orthopaedic fellowship trainees (34). In Finland, the publicly funded hospitals bear a century-old constitutional responsibility to provide necessary health care to all citizens, and thus, the structure of the national health care system and training programmes may be more uniform than in the USA. We observed a fairly constant proportion of the procedures performed in publicly funded university hospitals during the studied year-cohorts (Table 10), but also we did observe a distinct difference in surgery rates between the university hospital districts of Oulu and Turku (Figure 8), which might imply differences in regional treatment practices or background incidence.

After the change in the reimbursement system, we did not observe a clear change in the trend of shoulder capsular surgery procedure incidence rates; instead the rates remained essentially the same. As the overall increase in incidence was seen most in private hospitals, the insurance companies may have referred some of the patients who would otherwise have been treated in public hospitals to private hospitals due to better availability of treating surgeons, faster access to treatment, and lower total expenses.

It is plausible, that to a small degree, the regional differences in the variation of surgery procedure rates can also be due to differences in patient attitudes. Moreover, surgeons' attitude, beliefs, and decision-making regarding indications for surgery may also affect the executed surgical procedures (26-28, 330). Even though newer techniques and instrumentation provide similar rather than superior outcomes from the surgeons' point of view compared with older techniques, the treatment habits may still change (331). Generally, patients' expectations of surgical repair of shoulder instability are high (307). According to a survey, 92% of patients had a solid preference for arthroscopic surgery over open surgery methods. If only an open procedure was offered, the patient was more likely to decline surgery. In addition, almost all of the patients with previous shoulder surgery would prefer an arthroscopic procedure in the future. Patients also expected less pain, faster recovery, and superior functional outcomes with the arthroscopic approach (42). Furthermore, it is plausible that a patient prefers an arthroscopic procedure for improved cosmetic appearance. Therefore, patients' expectations are likely to influence the increasing shift of surgery from open to arthroscopic and the rising increase in incidence of surgery overall.

6.4 LIMITATIONS (I, II, III, IV)

The findings in our SR as well as in the majority of the published literature are applicable only to patients with minor bony lesions of the glenoid, as significant bony defects were excluded in all but one of the RCTs (51). We observed that in the included RCTs the use of instability-related shoulder function measurement was rare (22, 46-52), and the baseline values were even more seldom reported (49, 52). Therefore, a certain shortcoming in the clinical relevance of the performed SR and the current literature is that the impact of shoulder instability on patients' QoL or shoulder function remains largely unknown.

Type II error is generally present in orthopaedic literature (332), which is the case in shoulder instability literature as well, as commonly the publications did not meet the assumptions of the established power calculations. We observed a significant publication bias in the treatment of primary traumatic shoulder dislocation and more specifically in immobilization in ER versus IR, noting that the same amount of studies that have been published on the subject have remained unpublished, despite being registered in the trial database (Appendix Table 1). It is well known that studies with “negative results” for a certain intervention are more likely to remain unpublished (333), which increases the odds of overestimation of the true effect in MAs. A methodological limitation is that we did not perform sensitivity analyses or meta-regression analyses. (I)

We were compelled to analyse the performed shoulder capsular surgery procedures without meticulous categorization since the Finnish translation of procedure codes in shoulder capsular surgery is poor and the codes are inconsistently used. According to the coding, it is only possible to state that a shoulder capsular surgery procedure has been performed, but a distinct classification of a performed subtype of a procedure (e.g. anterior LR, capsular shift, SLAP (superior labrum anterior to posterior) repair) is impossible. Any of the procedure codes NBE25, NBE35, and NBE45 can be used to describe a performed arthroscopic LR, and therefore, our register material may also include surgical interventions performed due to a SLAP injury. In surgical treatment of shoulder instability in Finland, the procedure codes NBE35 and NBE45 result in higher billing and might therefore be used more than the procedure code NBE25. The confusion in the coding may lead to incorrect codes assigned to the procedures performed. However, in our opinion, the chosen diagnosis-procedure combinations in our material represent shoulder capsular surgery in Finland to a clinically relevant extent.

Although we have nationally comprehensive register data covering 10-year cohorts, these allowed us to study the trend of shoulder capsular surgery procedures only up to the year 2008 and for only four year-cohorts after the change in the reimbursement system in the procedure code billing. On the other hand, considering the natural experiment of the reimbursement system change, we have data on several years after the change to study the trend in general as well as the distribution of the procedures. Since we could not separate patients according to their insurance status, it is impossible to distinguish whether the injury was compensated by statutory or optional insurance. In addition, it is unknown how much money the insurance companies compensate annually or what proportion of injuries occur in traffic, in leisure, or in labour. (II, III)

Due to the retrospective nature of our study concerning the prevalence of glenohumeral OA after arthroscopic LR, the patient might not have recalled the date, circumstances, and energy of the trauma causing the primary shoulder dislocation, or the number of subsequent shoulder dislocations or subluxations. Furthermore, we did not have preoperative radiographs available because the storing policy had changed and the radiographs had been destroyed, nor did we have preoperative data on shoulder function. Moreover, the LR had been performed using bioabsorbable tacks that are no longer largely in use. Finally, we could not contact 20 patients of the identified 101 patients, which might have caused additional selection bias.

On the other hand, only one experienced senior orthopaedic surgeon performed all of the surgical procedures, and therefore, the procedure itself was highly standardized, and one independent assessor performed all of the outcome assessments. The arthroscopic LR has remained fairly constant for the last 15 to 20 years, and our follow-up of 13 years is relatively long. (IV)

6.5 CLINICAL IMPLICATIONS (I, II, III, IV)

After the primary shoulder dislocation, the shoulder can still be immobilized the conventional way in IR, as the immobilization in ER does not reduce recurrent shoulder instability. In treatment after a first-time shoulder dislocation, LR is effective in prevention of recurrent shoulder dislocations in typical patients (i.e. young and physically active men); however, the results are not generalizable to the general population or women. Surgery does seem to effectively reduce recurrent shoulder instability episodes in treatment of chronic post-traumatic shoulder instability, but the role of arthroscopic LR should be elucidated (I).

In the future, symptomatic shoulder instability should be the indication for surgical intervention. According to the current trend of shoulder capsular surgery procedures, the need to carefully consider NSM cannot be overstated, as the rising incidence of shoulder capsular surgery procedures cannot be unconditionally supported. To benefit from accurate register data, we should also demand unambiguous diagnosis and procedure coding and meticulous precision from every surgeon in reporting of the performed procedures. The new reimbursement system of occupational and traffic insurance system may have on effect on the treatment decisions and current practice, increasing the total treatment costs instead of producing the savings anticipated (II, III).

Arthroscopic LR with bioabsorbable tacks does not contribute to the development of glenohumeral OA, and as the patients are satisfied with the surgery outcome and are fairly asymptomatic in the long run, arthroscopic LR is a safe treatment option (IV).

6.6 FUTURE RESEARCH (I, II, III, IV)

The rise in the incidence and proportion of arthroscopic shoulder capsular surgery procedures is indisputable. The trend is not globally verified, although some studies have published similar results. Age group-specific up-to-date reports of the incidence of shoulder dislocations, general shoulder capsular surgery rates, and specific procedure types are required to potentially justify the increasing procedure rates. We need high-quality disease-specific national shoulder registers to supervise the quality and effectiveness of the treatment, analyse clinical data, and improve treatment chains. Also needed is accurate information on the indication for the surgical procedure, i.e. primary (traumatic) shoulder dislocation, chronic (post-traumatic) shoulder instability, ligamentous or labral pathology diagnosed in imaging, or pain. If insurance companies would provide data on compensations for certain treatments, it would give us a valuable perspective on the actual savings by the change in the reimbursement system and the shift of patients' treatments towards privately funded hospitals.

As the fixation method of capsulolabral pathology in the treatment of anterior shoulder instability has changed largely to suture anchors, and glenohumeral OA develops slowly, we need new even longer-term follow-up studies to determine whether the risk for glenohumeral OA is similar in patients treated with the suture anchor fixation method as in those formerly treated with bioabsorbable tacks, as we anticipate. The role of shoulder dislocation(s), NSM, and surgery should be verified and investigated in more detail in the evolution of glenohumeral OA in long-term prospective and randomized study settings.

The lack of evidence of effectiveness has an impact on daily treatment decisions of patients with shoulder instability symptoms, as the ideal physiotherapy routine for NSM after a first-time traumatic shoulder dislocation or for chronic post-traumatic shoulder instability is absent. Future trials should be adequately designed, powered, and reported, and they should use routinely validated measures to study shoulder function and the impact of shoulder dislocation or shoulder instability surgery on shoulder function as a main outcome with respect to the shoulder redislocation rate. While placebo effect is probably high in surgical interventions, further trials should be double-blinded and placebo-controlled when the aim is to assess intervention effect per se (50, 334-336). Also, to facilitate clinical decision-making, we should establish a risk counter that estimates subsequent individual risk for recurrent instability episodes after a shoulder dislocation of traumatic origin to evaluate whether surgery should be performed in the first place. We would also receive valuable information on the condition as a whole if we were to study patients with potentially higher risk of redislocations in a randomized controlled setting, also investigating whether a primary shoulder dislocation should be surgically treated instantly or after a recurrent dislocation. In addition, the cost-effectiveness of different treatment strategies of shoulder instability should be evaluated in Finland.

7 CONCLUSIONS (I, II, III, IV)

The following conclusions can be drawn from this study:

1) Moderate evidence for a first-time traumatic shoulder dislocation treated with LR shows that it leads to fewer redislocations than NSM, but routine surgery can still be considered overtreatment in young and physically active men. In treatment of chronic post-traumatic shoulder instability, open LR reduced the recurrent instability episodes compared with arthroscopic LR with low-quality evidence, but the overall effectiveness of surgery relative to NSM remains unknown.

2) The incidence of shoulder capsular surgery and arthroscopic procedures in particular have increased significantly throughout Finland, with a distinct geographical variation that might indicate differences in regional treatment practices or background incidence. Shoulder capsular surgery procedures are performed also on older patients, and therefore, well-defined indications for surgery are needed so that the operations are performed on symptomatic patients most likely to benefit regardless of patients' age.

3) The change in the reimbursement system for occupational and traffic insurance seems to have directed patients towards privately funded hospitals for surgery, but we did not observe a distinct change in the overall trend of incidence. Insurance companies may refer patients to

private hospitals because of better availability of treating surgeons, faster access to treatment, and lower total expenses.

4) In the long run, the prevalence of radiologically evaluated glenohumeral OA is rather common, but it is mostly graded as mild. Mild glenohumeral OA and shoulder instability cause only a minor defect in patients' shoulder function, with few objective findings.

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REFERENCES

1. Yang NP, Chen HC, Phan DV, Yu IL, Lee YH, Chan CL, Chou P, Renn JH. Epidemiological survey of orthopedic joint dislocations based on nationwide insurance data in Taiwan, 2000-2005. BMC Musculoskelet Disord. 2011;12:253.

2. Hayes K, Callanan M, Walton J, Paxinos A, Murrell GA. Shoulder instability: management and rehabilitation. J Orthop Sports Phys Ther. 2002;32(10):497-509.

3. Rowe CR. Prognosis in dislocations of the shoulder. J Bone Joint Surg Am. 1956;38-A(5):957-77.

4. Olds MK, Ellis R, Parmar P, Kersten P. Who will redislocate his/her shoulder? Predicting recurrent instability following a first traumatic anterior shoulder dislocation. BMJ Open Sport Exerc Med. 2019;5(1):e000447.

5. Taylor DC, Arciero RA. Pathologic changes associated with shoulder dislocations. Arthroscopic and physical examination findings in first-time, traumatic anterior dislocations. Am J Sports Med. 1997;25(3):306-11.

6. Robinson CM, Dobson RJ. Anterior instability of the shoulder after trauma. J Bone Joint Surg Br. 2004;86(4):469-79.

7. Lynch JR, Clinton JM, Dewing CB, Warme WJ, Matsen FA, 3rd. Treatment of osseous defects associated with anterior shoulder instability. J Shoulder Elbow Surg. 2009;18(2):317-28.

8. Kroner K, Lind T, Jensen J. The epidemiology of shoulder dislocations. Arch Orthop Trauma Surg. 1989;108(5):288-90.

9. Liavaag S, Svenningsen S, Reikeras O, Enger M, Fjalestad T, Pripp AH, Brox JI. The epidemiology of shoulder dislocations in Oslo. Scand J Med Sci Sports. 2011;21(6):e334-40.

10. Leroux T, Wasserstein D, Veillette C, Khoshbin A, Henry P, Chahal J, Austin P, Mahomed N, Ogilvie-Harris D. Epidemiology of primary anterior shoulder dislocation requiring closed reduction in Ontario, Canada. Am J Sports Med. 2014;42(2):442-50.

11. Olds M, Ellis R, Donaldson K, Parmar P, Kersten P. Risk factors which predispose first-time traumatic anterior shoulder dislocations to recurrent instability in adults: a systematic review and meta-analysis. Br J Sports Med. 2015;49(14):913-22.

12. Wasserstein DN, Sheth U, Colbenson K, Henry PD, Chahal J, Dwyer T, Kuhn JE. The True Recurrence Rate and Factors Predicting Recurrent Instability After Nonsurgical Management

of Traumatic Primary Anterior Shoulder Dislocation: A Systematic Review. Arthroscopy. 2016;32(12):2616-25.

13. Youm T, Takemoto R, Park BK. Acute management of shoulder dislocations. J Am Acad Orthop Surg. 2014;22(12):761-71.

14. Handoll Helen HG, Al-Maiyah Mohammed A. Surgical versus non-surgical treatment for acute anterior shoulder dislocation. Cochrane Database Syst Rev. 2004;(1):CD004325. Review.

15. Dala-Ali B, Penna M, McConnell J, Vanhegan I, Cobiella C. Management of acute anterior shoulder dislocation. Br J Sports Med. 2014;48(16):1209-15.

16. Thangarajah T, Lambert S. Management of the unstable shoulder. BMJ. 2015;350:h2537.

17. Hanchard NC, Goodchild LM, Kottam L. Conservative management following closed reduction of traumatic anterior dislocation of the shoulder. Cochrane Database Syst Rev. 2014;4(4):CD004962.

18. Whelan DB, Kletke SN, Schemitsch G, Chahal J. Immobilization in External Rotation Versus Internal Rotation After Primary Anterior Shoulder Dislocation: A Meta-analysis of Randomized Controlled Trials. Am J Sports Med. 2016;44(2):521-32.

19. Vavken P, Sadoghi P, Quidde J, Lucas R, Delaney R, Mueller AM, Rosso C, Valderrabano V. Immobilization in internal or external rotation does not change recurrence rates after traumatic anterior shoulder dislocation. J Shoulder Elbow Surg. 2014;23(1):13-9.

20. Liu A, Xue X, Chen Y, Bi F, Yan S. The external rotation immobilisation does not reduce recurrence rates or improve quality of life after primary anterior shoulder dislocation: a systematic review and meta-analysis. Injury. 2014;45(12):1842-7.

21. Johnson SM, Robinson CM. Shoulder instability in patients with joint hyperlaxity. J Bone Joint Surg Am. 2010;92(6):1545-57.

22. Kirkley A, Griffin S, Richards C, Miniaci A, Mohtadi N. Prospective randomized clinical trial comparing the effectiveness of immediate arthroscopic stabilization versus immobilization and rehabilitation in first traumatic anterior dislocations of the shoulder. Arthroscopy. 1999;15(5):507-14.

23. Hovelius L, Rahme H. Primary anterior dislocation of the shoulder: long-term prognosis at the age of 40 years or younger. Knee Surg Sports Traumatol Arthrosc. 2016;24(2):330-42.

24. Cameron KL, Mauntel TC, Owens BD. The Epidemiology of Glenohumeral Joint Instability: Incidence, Burden, and Long-term Consequences. Sports Med Arthrosc Rev. 2017;25(3):144-9.

25. Gaskill TR, Taylor DC, Millett PJ. Management of multidirectional instability of the shoulder. J Am Acad Orthop Surg. 2011;19(12):758-67.

26. Balke M, Shafizadeh S, Bouillon B, Banerjee M. Management of shoulder instability: the current state of treatment among German orthopaedic surgeons. Arch Orthop Trauma Surg. 2016;136(12):1717-21.

27. Malhotra A, Freudmann MS, Hay SM. Management of traumatic anterior shoulder dislocation in the 17- to 25-year age group: a dramatic evolution of practice. J Shoulder Elbow Surg. 2012;21(4):545-53.

28. Weel H, Tromp W, Krekel PR, Randelli P, van den Bekerom MP, van Deurzen DF. International survey and surgeon's preferences in diagnostic work-up towards treatment of anterior shoulder instability. Arch Orthop Trauma Surg. 2016;136(6):741-6.

29. Virk MS, Manzo RL, Cote M, Ware JK, Mazzocca AD, Nissen CW, Shea KP, Arciero RA. Comparison of Time to Recurrence of Instability After Open and Arthroscopic Bankart Repair Techniques. Orthop J Sports Med. 2016;4(6):2325967116654114.

30. Chahal J, Marks PH, Macdonald PB, Shah PS, Theodoropoulos J, Ravi B, Whelan DB. Anatomic Bankart repair compared with nonoperative treatment and/or arthroscopic lavage for first-time traumatic shoulder dislocation. Arthroscopy. 2012;28(4):565-75.

31. Brophy RH, Marx RG. The treatment of traumatic anterior instability of the shoulder: nonoperative and surgical treatment. Arthroscopy. 2009;25(3):298-304.

32. Forsythe B, Frank RM, Ahmed M, Verma NN, Cole BJ, Romeo AA, Provencher MT, Nho SJ. Identification and treatment of existing copathology in anterior shoulder instability repair. Arthroscopy. 2015;31(1):154-66.

33. Blomquist J, Solheim E, Liavaag S, Schroder CP, Espehaug B, Havelin LI. Shoulder instability surgery in Norway: the first report from a multicenter register, with 1-year follow-up. Acta Orthop. 2012;83(2):165-70.

34. Owens BD, Harrast JJ, Hurwitz SR, Thompson TL, Wolf JM. Surgical trends in Bankart repair: an analysis of data from the American Board of Orthopaedic Surgery certification examination. Am J Sports Med. 2011;39(9):1865-9.

35. Zhang AL, Kreulen C, Ngo SS, Hame SL, Wang JC, Gamradt SC. Demographic trends in arthroscopic SLAP repair in the United States. Am J Sports Med. 2012;40(5):1144-7.

36. Zhang AL, Montgomery SR, Ngo SS, Hame SL, Wang JC, Gamradt SC. Arthroscopic versus open shoulder stabilization: current practice patterns in the United States. Arthroscopy. 2014;30(4):436-43.

37. Wasserstein D, Dwyer T, Veillette C, Gandhi R, Chahal J, Mahomed N, Ogilvie-Harris D. Predictors of dislocation and revision after shoulder stabilization in Ontario, Canada, from 2003 to 2008. Am J Sports Med. 2013;41(9):2034-40.

38. Onyekwelu I, Khatib O, Zuckerman JD, Rokito AS, Kwon YW. The rising incidence of arthroscopic superior labrum anterior and posterior (SLAP) repairs. J Shoulder Elbow Surg. 2012;21(6):728-31.

39. Riff AJ, Frank RM, Sumner S, Friel N, Bach BR, Jr., Verma NN, Romeo AA. Trends in Shoulder Stabilization Techniques Used in the United States Based on a Large Private-Payer Database. Orthop J Sports Med. 2017;5(12):2325967117745511.

40. Bonazza NA, Liu G, Leslie DL, Dhawan A. Trends in Surgical Management of Shoulder Instability. Orthop J Sports Med. 2017;5(6):2325967117712476.

41. Major NM, Browne J, Domzalski T, Cothran RL, Helms CA. Evaluation of the glenoid labrum with 3-T MRI: is intraarticular contrast necessary? AJRAmerican journal of roentgenology. 2011;196(5):1139-44.

42. Sperling JW, Smith AM, Cofield RH, Barnes S. Patient perceptions of open and arthroscopic shoulder surgery. Arthroscopy. 2007;23(4):361-6.

43. Simmen BR, Angst F, Schwyzer HK, Herren DB, Pap G, Aeschlimann A, Goldhahn J. A concept for comprehensively measuring health, function and quality of life following orthopaedic interventions of the upper extremity. Arch Orthop Trauma Surg. 2009;129(1):113-8.

44. Kirkley A, Griffin S, Dainty K. Scoring systems for the functional assessment of the shoulder. Arthroscopy. 2003;19(10):1109-20.

45. Hovelius L, Nilsson JA, Nordqvist A. Increased mortality after anterior shoulder dislocation: 255 patients aged 12-40 years followed for 25 years. Acta Orthop. 2007;78(6):822-6.

46. Heidari K, Asadollahi S, Vafaee R, Barfehei A, Kamalifar H, Chaboksavar ZA, Sabbaghi M. Immobilization in external rotation combined with abduction reduces the risk of recurrence after primary anterior shoulder dislocation. J Shoulder Elbow Surg. 2014;23(6):759-66.

47. Liavaag S, Svenningsen S, Reikeras O, Enger M, Fjalestad T, Pripp AH, Brox JI. The epidemiology of shoulder dislocations in Oslo. Scandinavian Journal of Medicine & Science in Sports. 2011;21(6):e334-40.

48. Kirkley A, Werstine R, Ratjek A, Griffin S. Prospective randomized clinical trial comparing the effectiveness of immediate arthroscopic stabilization versus immobilization and rehabilitation in first traumatic anterior dislocations of the shoulder: long-term evaluation. Arthroscopy. 2005;21(1):55-63.

49. Mohtadi NG, Chan DS, Hollinshead RM, Boorman RS, Hiemstra LA, Lo IK, Hannaford HN, Fredine J, Sasyniuk TM, Paolucci EO. A randomized clinical trial comparing open and arthroscopic stabilization for recurrent traumatic anterior shoulder instability: two-year follow-up with disease-specific quality-of-life outcomes. J Bone Joint Surg Am. 2014;96(5):353-60.

50. Robinson CM, Jenkins PJ, White TO, Ker A, Will E. Primary arthroscopic stabilization for a first-time anterior dislocation of the shoulder. A randomized, double-blind trial. J Bone Joint Surg Am. 2008;90(4):708-21.

51. Salomonsson B, Abbaszadegan H, Revay S, Lillkrona U. The Bankart repair versus the Putti-Platt procedure: a randomized study with WOSI score at 10-year follow-up in 62 patients. Acta Orthop. 2009;80(3):351-6.

52. Whelan DB, Litchfield R, Wambolt E, Dainty KN, Joint Orthopaedic Initiative for National Trials of the S. External rotation immobilization for primary shoulder dislocation: a randomized controlled trial. Clinical orthopaedics and related research. 2014;472(8):2380-6.

53. Brox JI, Lereim P, Merckoll E, Finnanger AM. Radiographic classification of glenohumeral arthrosis. Acta Orthop Scand. 2003;74(2):186-9.

54. Hovelius L, Saeboe M. Neer Award 2008: Arthropathy after primary anterior shoulder dislocation-223 shoulders prospectively followed up for twenty-five years. J Shoulder Elb Surg. 2009;18(3):339-47.

55. Plath JE, Aboalata M, Seppel G, Juretzko J, Waldt S, Vogt S, Imhoff AB. Prevalence of and Risk Factors for Dislocation Arthropathy: Radiological Long-term Outcome of Arthroscopic Bankart Repair in 100 Shoulders at an Average 13-Year Follow-up. The American Journal of Sports Medicine. 2015;43(5):1084-90.

56. Gordins V, Hovelius L, Sandstrom B, Rahme H, Bergstrom U. Risk of arthropathy after the Bristow-Latarjet repair: a radiologic and clinical thirty-three to thirty-five years of follow-up of thirty-one shoulders. J Shoulder Elbow Surg. 2015;24(5):691-9.

57. Elmlund AO, Ejerhed L, Sernert N, Rostgard LC, Kartus J. Dislocation arthropathy and drill hole appearance in a mid- to long-term follow-up study after arthroscopic Bankart repair. Knee Surg Sports Traumatol Arthrosc. 2012;20(11):2156-62.

58. Cook TS, Stein JM, Simonson S, Kim W. Normal and variant anatomy of the shoulder on MRI. Magn Reson Imaging Clin N Am. 2011;19(3):581-94.

59. Lawrence RL, Braman JP, Laprade RF, Ludewig PM. Comparison of 3-dimensional shoulder complex kinematics in individuals with and without shoulder pain, part 1: sternoclavicular, acromioclavicular, and scapulothoracic joints. J Orthop Sports Phys Ther. 2014;44(9):636-45, A1-8.

60. Cuellar R, Ruiz-Iban MA, Cuellar A. Anatomy and Biomechanics of the Unstable Shoulder. Open Orthop J. 2017;11:919-33.

61. Rudez J, Zanetti M. Normal anatomy, variants and pitfalls on shoulder MRI. Eur J Radiol. 2008;68(1):25-35.

62. Lugo R, Kung P, Ma CB. Shoulder biomechanics. Eur J Radiol. 2008;68(1):16-24.

63. Gil JA, DeFroda S, Owens BD. Current Concepts in the Diagnosis and Management of Traumatic, Anterior Glenohumeral Subluxations. Orthop J Sports Med. 2017;5(3):2325967117694338.

64. Michelin P, Trintignac A, Dacher JN, Carvalhana G, Lefebvre V, Duparc F. Magnetic resonance anatomy of the superior part of the rotator cuff in normal shoulders, assessment and practical implication. Surg Radiol Anat. 2014;36(10):993-1000.

65. Curtis AS, Burbank KM, Tierney JJ, Scheller AD, Curran AR. The insertional footprint of the rotator cuff: an anatomic study. Arthroscopy. 2006;22(6):609 e1.

66. De Maeseneer M, Van Roy P, Shahabpour M. Normal MR imaging anatomy of the rotator cuff tendons, glenoid fossa, labrum, and ligaments of the shoulder. Magn Reson Imaging Clin N Am. 2004;12(1):1-10, v.

67. Dunham KS, Bencardino JT, Rokito AS. Anatomic variants and pitfalls of the labrum, glenoid cartilage, and glenohumeral ligaments. Magn Reson Imaging Clin N Am. 2012;20(2):213-28, x.

68. Motamedi D, Everist BM, Mahanty SR, Steinbach LS. Pitfalls in shoulder MRI: part 1--normal anatomy and anatomic variants. AJR Am J Roentgenol. 2014;203(3):501-7.

69. Boulet C, De Maeseneer M, Pouliart N, De Mey J, Handelberg F, Shahabpour M. Magnetic resonance arthrography of glenohumeral lesions: anatomy and arthroscopically confirmed pathology. Can Assoc Radiol J. 2012;63(2):79-86.

70. O'Brien SJ, Neves MC, Arnoczky SP, Rozbruck SR, Dicarlo EF, Warren RF, Schwartz R, Wickiewicz TL. The anatomy and histology of the inferior glenohumeral ligament complex of the shoulder. Am J Sports Med. 1990;18(5):449-56.

71. Hill AM, Hoerning EJ, Brook K, Smith CD, Moss J, Ryder T, Wallace AL, Bull AM. Collagenous microstructure of the glenoid labrum and biceps anchor. J Anat. 2008;212(6):853-62.

72. Kadi R. Shoulder Anatomy and Normal Variants. Journal of the Belgian Society of Radiology. 2017;101(S2: 3).

73. Gombera MM, Sekiya JK. Rotator cuff tear and glenohumeral instability : a systematic review. Clin Orthop Relat Res. 2014;472(8):2448-56.

74. Abboud JA, Soslowsky LJ. Interplay of the static and dynamic restraints in glenohumeral instability. Clin Orthop Relat Res. 2002(400):48-57.

75. Howell SM, Galinat BJ. The glenoid-labral socket. A constrained articular surface. Clin Orthop Relat Res. 1989(243):122-5.

76. Warner JJ, Deng X, Warren RF, Torzilli PA, O'Brien SJ. Superoinferior translation in the intact and vented glenohumeral joint. J Shoulder Elbow Surg. 1993;2(2):99-105.

77. Farrar NG, Malal JJ, Fischer J, Waseem M. An overview of shoulder instability and its management. Open Orthop J. 2013;7:338-46.

78. Myers JB, Wassinger CA, Lephart SM. Sensorimotor contribution to shoulder stability: effect of injury and rehabilitation. Man Ther. 2006;11(3):197-201.

79. Salles JI, Velasques B, Cossich V, Nicoliche E, Ribeiro P, Amaral MV, Motta G. Strength training and shoulder proprioception. J Athl Train. 2015;50(3):277-80.

80. Edouard P, Gasq D, Calmels P, Degache F. Sensorimotor control deficiency in recurrent anterior shoulder instability assessed with a stabilometric force platform. J Shoulder Elbow Surg. 2014;23(3):355-60.

81. Bankart AS, Cantab MC. Recurrent or habitual dislocation of the shoulder-joint. 1923. Clin Orthop Relat Res. 1993(291):3-6.

82. Perthes G. Über Operationen bei habitueller Schulterluxation. Deutsche Zeitschr Chir. 1906;85:199-227.

83. Speer KP, Deng X, Borrero S, Torzilli PA, Altchek DA, Warren RF. Biomechanical evaluation of a simulated Bankart lesion. J Bone Joint Surg Am. 1994;76(12):1819-26.

84. Neviaser TJ. The anterior labroligamentous periosteal sleeve avulsion lesion: a cause of anterior instability of the shoulder. Arthroscopy. 1993;9(1):17-21.

85. Wischer TK, Bredella MA, Genant HK, Stoller DW, Bost FW, Tirman PF. Perthes lesion (a variant of the Bankart lesion): MR

imaging and MR arthrographic findings with surgical correlation. AJR Am J Roentgenol. 2002;178(1):233-7.

86. Neviaser TJ. The GLAD lesion: another cause of anterior shoulder pain. Arthroscopy. 1993;9(1):22-3.

87. Woertler K, Waldt S. MR imaging in sports-related glenohumeral instability. Eur Radiol. 2006;16(12):2622-36.

88. Mizuno N, Yoneda M, Nakagawa S, Hayashida K. The pathology of the anterior capsule in patients over forty years of age with recurrent shoulder dislocation. Int Orthop. 2016;40(1):81-6.

89. Paxton ES, Dodson CC, Lazarus MD. Shoulder instability in older patients. Orthop Clin North Am. 2014;45(3):377-85.

90. Reeves B. Experiments on the tensile strength of the anterior capsular structures of the shoulder in man. J Bone Joint Surg Br. 1968;50(4):858-65.

91. Porcellini G, Paladini P, Campi F, Paganelli M. Shoulder instability and related rotator cuff tears: arthroscopic findings and treatment in patients aged 40 to 60 years. Arthroscopy. 2006;22(3):270-6.

92. Kim DS, Yoon YS, Yi CH. Prevalence comparison of accompanying lesions between primary and recurrent anterior dislocation in the shoulder. Am J Sports Med. 2010;38(10):2071-6.

93. Porcellini G, Caranzano F, Campi F, Pellegrini A, Paladini P. Glenohumeral instability and rotator cuff tear. Sports Med Arthrosc. 2011;19(4):395-400.

94. Goldberg JA, Chan KY, Best JP, Bruce WJ, Walsh W, Parry W. Surgical management of large rotator cuff tears combined with instability in elite rugby football players. Br J Sports Med. 2003;37(2):179-81; discussion 81.

95. Stefko JM, Tibone JE, Cawley PW, ElAttrache NE, McMahon PJ. Strain of the anterior band of the inferior glenohumeral ligament during capsule failure. J Shoulder Elbow Surg. 1997;6(5):473-9.

96. McMahon PJ, Dettling J, Sandusky MD, Tibone JE, Lee TQ. The anterior band of the inferior glenohumeral ligament. Assessment of its permanent deformation and the anatomy of its glenoid attachment. J Bone Joint Surg Br. 1999;81(3):406-13.

97. Chen AL, Hunt SA, Hawkins RJ, Zuckerman JD. Management of bone loss associated with recurrent anterior glenohumeral instability. Am J Sports Med. 2005;33(6):912-25.

98. Itoi E, Lee SB, Berglund LJ, Berge LL, An KN. The effect of a glenoid defect on anteroinferior stability of the shoulder after Bankart repair: a cadaveric study. J Bone Joint Surg Am. 2000;82(1):35-46.

99. Lo IK, Parten PM, Burkhart SS. The inverted pear glenoid: an indicator of significant glenoid bone loss. Arthroscopy. 2004;20(2):169-74.

100. Mologne TS, Provencher MT, Menzel KA, Vachon TA, Dewing CB. Arthroscopic stabilization in patients with an inverted pear glenoid: results in patients with bone loss of the anterior glenoid. Am J Sports Med. 2007;35(8):1276-83.

101. Trivedi S, Pomerantz ML, Gross D, Golijanan P, Provencher MT. Shoulder instability in the setting of bipolar (glenoid and humeral head) bone loss: the glenoid track concept. Clin Orthop Relat Res. 2014;472(8):2352-62.

102. Provencher MT, Frank RM, Leclere LE, Metzger PD, Ryu JJ, Bernhardson A, Romeo AA. The Hill-Sachs lesion: diagnosis, classification, and management. J Am Acad Orthop Surg. 2012;20(4):242-52.

103. Yamamoto N, Itoi E, Abe H, Minagawa H, Seki N, Shimada Y, Okada K. Contact between the glenoid and the humeral head in abduction, external rotation, and horizontal extension: a new concept of glenoid track. J Shoulder Elbow Surg. 2007;16(5):649-56.

104. Burkhart SS, De Beer JF. Traumatic glenohumeral bone defects and their relationship to failure of arthroscopic Bankart repairs: significance of the inverted-pear glenoid and the humeral engaging Hill-Sachs lesion. Arthroscopy. 2000;16(7):677-94.

105. Murthi AM, Ramirez MA. Shoulder dislocation in the older patient. J Am Acad Orthop Surg. 2012;20(10):615-22.

106. Khiami F, Gerometta A, Loriaut P. Management of recent first-time anterior shoulder dislocations. Orthop Traumatol Surg Res. 2015;101(1 Suppl):S51-7.

107. Gutkowska O, Martynkiewicz J, Urban M, Gosk J. Brachial plexus injury after shoulder dislocation: a literature review. Neurosurg Rev. 2018.

108. Robinson CM, Shur N, Sharpe T, Ray A, Murray IR. Injuries associated with traumatic anterior glenohumeral dislocations. J Bone Joint Surg Am. 2012;94(1):18-26.

109. Johnson SF, Johnson SB, Strodel WE, Barker DE, Kearney PA. Brachial plexus injury: association with subclavian and axillary vascular trauma. J Trauma. 1991;31(11):1546-50.

110. Kirkley A, Griffin S, McLintock H, Ng L. The development and evaluation of a disease-specific quality of life measurement tool for shoulder instability. The Western Ontario Shoulder Instability Index (WOSI). Am J Sports Med. 1998;26(6):764-72.

111. Soderlund T, Mattila VM, Visuri TI, Pihlajamaki HK. Long-term outcome of a transglenoid suture technique for anterior shoulder

instability in young adults. Journal of Bone & Joint Surgery - British Volume. 2008;90(2):189-93.

112. Owens BD, Dawson L, Burks R, Cameron KL. Incidence of shoulder dislocation in the United States military: demographic considerations from a high-risk population. J Bone Joint Surg Am. 2009;91(4):791-6.

113. Owens BD, Duffey ML, Nelson BJ, DeBerardino TM, Taylor DC, Mountcastle SB. The incidence and characteristics of shoulder instability at the United States Military Academy. Am J Sports Med. 2007;35(7):1168-73.

114. Wolfe JA, Christensen DL, Mauntel TC, Owens BD, LeClere LE, Dickens JF. A History of Shoulder Instability in the Military: Where We Have Been and What We Have Learned. Mil Med. 2018.

115. Mallon WJ, Bassett FH, 3rd, Goldner RD. Luxatio erecta: the inferior glenohumeral dislocation. J Orthop Trauma. 1990;4(1):19-24.

116. Hovelius L, Augustini BG, Fredin H, Johansson O, Norlin R, Thorling J. Primary anterior dislocation of the shoulder in young patients. A ten-year prospective study. J Bone Joint Surg Am. 1996;78(11):1677-84.

117. Zacchilli MA, Owens BD. Epidemiology of shoulder dislocations presenting to emergency departments in the United States. J Bone Joint Surg Am. 2010;92(3):542-9.

118. Shields DW, Jefferies JG, Brooksbank AJ, Millar N, Jenkins PJ. Epidemiology of glenohumeral dislocation and subsequent instability in an urban population. J Shoulder Elbow Surg. 2018;27(2):189-95.

119. Robinson CM, Howes J, Murdoch H, Will E, Graham C. Functional outcome and risk of recurrent instability after primary traumatic anterior shoulder dislocation in young patients. J Bone Joint Surg Am. 2006;88(11):2326-36.

120. Owens BD, Nelson BJ, Duffey ML, Mountcastle SB, Taylor DC, Cameron KL, Campbell S, DeBerardino TM. Pathoanatomy of first-time, traumatic, anterior glenohumeral subluxation events. J Bone Joint Surg Am. 2010;92(7):1605-11.

121. Kuhn JE. A new classification system for shoulder instability. Br J Sports Med. 2010;44(5):341-6.

122. Chahal J, Kassiri K, Dion A, MacDonald P, Leiter J. Diagnostic and treatment differences among experienced shoulder surgeons for instability conditions of the shoulder. Clin J Sport Med. 2007;17(1):5-9.

123. McFarland EG, Kim TK, Park HB, Neira CA, Gutierrez MI. The effect of variation in definition on the diagnosis of

multidirectional instability of the shoulder. J Bone Joint Surg Am. 2003;85-A(11):2138-44.

124. Burbank KM, Stevenson JH, Czarnecki GR, Dorfman J. Chronic shoulder pain: part I. Evaluation and diagnosis. Am Fam Physician. 2008;77(4):453-60.

125. Cameron KL, Duffey ML, DeBerardino TM, Stoneman PD, Jones CJ, Owens BD. Association of generalized joint hypermobility with a history of glenohumeral joint instability. J Athl Train. 2010;45(3):253-8.

126. Flint JH, Pickett A, Owens BD, Svoboda SJ, Peck KY, Cameron KL, Biery J, Giuliani J, Rue JP. Recurrent Shoulder Instability in a Young, Active, Military Population and Its Professional Implications. Sports Health. 2018;10(1):54-9.

127. Carpinteiro EP, Barros AA. Natural History of Anterior Shoulder Instability. Open Orthop J. 2017;11:909-18.

128. Tjong VK, Devitt BM, Murnaghan ML, Ogilvie-Harris DJ, Theodoropoulos JS. A Qualitative Investigation of Return to Sport After Arthroscopic Bankart Repair: Beyond Stability. Am J Sports Med. 2015;43(8):2005-11.

129. Doukas WC, Speer KP. Anatomy, pathophysiology, and biomechanics of shoulder instability. Orthop Clin North Am. 2001;32(3):381-91, vii.

130. Saccomanno MF, Fodale M, Capasso L, Cazzato G, Milano G. Generalized joint laxity and multidirectional instability of the shoulder. Joints. 2014;1(4):171-9.

131. Navlet MG, Asenjo-Gismero CV. Multidirectional Instability: Natural History and Evaluation. Open Orthop J. 2017;11:861-74.

132. Bahk M, Keyurapan E, Tasaki A, Sauers EL, McFarland EG. Laxity testing of the shoulder: a review. Am J Sports Med. 2007;35(1):131-44.

133. Lippitt SB, Harris SL, Harryman DT, 2nd, Sidles J, Matsen FA, 3rd. In vivo quantification of the laxity of normal and unstable glenohumeral joints. J Shoulder Elbow Surg. 1994;3(4):215-23.

134. Harryman DT, 2nd, Sidles JA, Harris SL, Matsen FA, 3rd. Laxity of the normal glenohumeral joint: A quantitative in vivo assessment. J Shoulder Elbow Surg. 1992;1(2):66-76.

135. Kiss J, Damrel D, Mackie A, Neumann L, Wallace WA. Non-operative treatment of multidirectional shoulder instability. Int Orthop. 2001;24(6):354-7.

136. Monk AP, Garfjeld Roberts P, Logishetty K, Price AJ, Kulkarni R, Rangan A, Rees JL. Evidence in managing traumatic anterior shoulder instability: a scoping review. Br J Sports Med. 2015;49(5):307-11.

137. te Slaa RL, Wijffels MP, Brand R, Marti RK. The prognosis following acute primary glenohumeral dislocation. Journal of Bone & Joint Surgery - British Volume. 2004;86(1):58-64.

138. Cadet ER. Evaluation of glenohumeral instability. Orthop Clin North Am. 2010;41(3):287-95.

139. Barrett C. The clinical physiotherapy assessment of non-traumatic shoulder instability. Shoulder Elbow. 2015;7(1):60-71.

140. Woodward TW, Best TM. The painful shoulder: part I. Clinical evaluation. Am Fam Physician. 2000;61(10):3079-88.

141. Hanchard NC, Lenza M, Handoll HH, Takwoingi Y. Physical tests for shoulder impingements and local lesions of bursa, tendon or labrum that may accompany impingement. Cochrane Database Syst Rev. 2013(4):CD007427.

142. Hegedus EJ, Goode AP, Cook CE, Michener L, Myer CA, Myer DM, Wright AA. Which physical examination tests provide clinicians with the most value when examining the shoulder? Update of a systematic review with meta-analysis of individual tests. Br J Sports Med. 2012;46(14):964-78.

143. Rowe CR, Zarins B. Recurrent transient subluxation of the shoulder. J Bone Joint Surg Am. 1981;63(6):863-72.

144. Jobe FW, Kvitne RS, Giangarra CE. Shoulder pain in the overhand or throwing athlete. The relationship of anterior instability and rotator cuff impingement. Orthop Rev. 1989;18(9):963-75.

145. Gross ML, Distefano MC. Anterior release test. A new test for occult shoulder instability. Clin Orthop Relat Res. 1997(339):105-8.

146. Smith TO, Drew BT, Toms AP. A meta-analysis of the diagnostic test accuracy of MRA and MRI for the detection of glenoid labral injury. Arch Orthop Trauma Surg. 2012;132(7):905-19.

147. Sedeek SM, Bin Abd Razak HR, Ee GW, Tan AH. First-time anterior shoulder dislocations: should they be arthroscopically stabilised? Singapore Med J. 2014;55(10):511-5; quiz 6.

148. Kahn JH, Mehta SD. The role of post-reduction radiographs after shoulder dislocation. J Emerg Med. 2007;33(2):169-73.

149. Markenstein JE, Jaspars KC, van der Hulst VP, Willems WJ. The quantification of glenoid bone loss in anterior shoulder instability; MR-arthro compared to 3D-CT. Skeletal Radiol. 2014;43(4):475-83.

150. Milano G, Saccomanno MF, Magarelli N, Bonomo L. Analysis of Agreement Between Computed Tomography Measurements of Glenoid Bone Defects in Anterior Shoulder Instability With and

Without Comparison With the Contralateral Shoulder. Am J Sports Med. 2015;43(12):2918-26.

151. Bishop JY, Jones GL, Rerko MA, Donaldson C, Group MS. 3-D CT is the most reliable imaging modality when quantifying glenoid bone loss. Clin Orthop Relat Res. 2013;471(4):1251-6.

152. Angst F, Schwyzer HK, Aeschlimann A, Simmen BR, Goldhahn J. Measures of adult shoulder function: Disabilities of the Arm, Shoulder, and Hand Questionnaire (DASH) and its short version (QuickDASH), Shoulder Pain and Disability Index (SPADI), American Shoulder and Elbow Surgeons (ASES) Society standardized shoulder assessment form, Constant (Murley) Score (CS), Simple Shoulder Test (SST), Oxford Shoulder Score (OSS), Shoulder Disability Questionnaire (SDQ), and Western Ontario Shoulder Instability Index (WOSI). Arthritis Care Res (Hoboken). 2011;63 Suppl 11:S174-88.

153. Schmidt S, Ferrer M, Gonzalez M, Gonzalez N, Valderas JM, Alonso J, Escobar A, Vrotsou K, Group E. Evaluation of shoulder-specific patient-reported outcome measures: a systematic and standardized comparison of available evidence. J Shoulder Elbow Surg. 2014;23(3):434-44.

154. Garratt A, Schmidt L, Mackintosh A, Fitzpatrick R. Quality of life measurement: bibliographic study of patient assessed health outcome measures. BMJ. 2002;324(7351):1417.

155. Kemp KA, Sheps DM, Beaupre LA, Styles-Tripp F, Luciak-Corea C, Balyk R. An evaluation of the responsiveness and discriminant validity of shoulder questionnaires among patients receiving surgical correction of shoulder instability. ScientificWorldJournal. 2012;2012:410125.

156. Dawson J, Fitzpatrick R, Carr A. The assessment of shoulder instability. The development and validation of a questionnaire. J Bone Joint Surg Br. 1999;81(3):420-6.

157. Rowe CR, Patel D, Southmayd WW. The Bankart procedure: a long-term end-result study. Journal of Bone & Joint Surgery - American Volume. 1978;60(1):1-16.

158. Richards RR, An KN, Bigliani LU, Friedman RJ, Gartsman GM, Gristina AG, Iannotti JP, Mow VC, Sidles JA, Zuckerman JD. A standardized method for the assessment of shoulder function. J Shoulder Elbow Surg. 1994;3(6):347-52.

159. Lippitt SB, Harryman DT, 2nd, Matsen FA, 3rd. A practical tool for evaluating function: the Simple Shoulder Test. Matsen FA, 3rd, Hawkins RJ, Fu FH, editors. Rosemont (Ill): American Academy of Orthopaedic Surgeons; 1993. 501–18 p.

160. Dawson JF, R. ; Carr, A. Questionnaire on the perceptions of patients about shoulder surgery. Journal of Bone & Joint Surgery - British Volume. 1996;78:593-600.

161. Roach KE, Budiman-Mak E, Songsiridej N, Lertratanakul Y. Development of a shoulder pain and disability index. Arthritis Care Res. 1991;4(4):143-9.

162. Constant CR, Murley AH. A clinical method of functional assessment of the shoulder. Clin Orthop Relat Res. 1987(214):160-4.

163. Kennedy CAB, D.E. ; Solway, S. ; McConnell, S. ; Bombardier, C. . The DASH outcome measure user's manual. 3rd ed. ed. Toronto, Canada: Institute for Work & Health; 2011.

164. Amstutz HC, Sew Hoy AL, Clarke IC. UCLA anatomic total shoulder arthroplasty. Clin Orthop Relat Res. 1981(155):7-20.

165. Rouleau DM, Faber K, MacDermid JC. Systematic review of patient-administered shoulder functional scores on instability. J Shoulder Elbow Surg. 2010;19(8):1121-8.

166. Wylie JD, Beckmann JT, Granger E, Tashjian RZ. Functional outcomes assessment in shoulder surgery. World J Orthop. 2014;5(5):623-33.

167. van der Linde JA, van Kampen DA, van Beers LW, van Deurzen DF, Terwee CB, Willems WJ. The Oxford Shoulder Instability Score; validation in Dutch and first-time assessment of its smallest detectable change. J Orthop Surg Res. 2015;10:146.

168. Galvin JW, Ernat JJ, Waterman BR, Stadecker MJ, Parada SA. The Epidemiology and Natural History of Anterior Shoulder Instability. Curr Rev Musculoskelet Med. 2017;10(4):411-24.

169. Kachooei AR, Talaei-Khoei M, Faghfouri A, Ring D. Factors associated with operative treatment of enthesopathy of the extensor carpi radialis brevis origin. J Shoulder Elbow Surg. 2016;25(4):666-70.

170. Kanji A, Atkinson P, Fraser J, Lewis D, Benjamin S. Delays to initial reduction attempt are associated with higher failure rates in anterior shoulder dislocation: a retrospective analysis of factors affecting reduction failure. Emerg Med J. 2016;33(2):130-3.

171. Wakai A, O'Sullivan R, McCabe A. Intra-articular lignocaine versus intravenous analgesia with or without sedation for manual reduction of acute anterior shoulder dislocation in adults. Cochrane Database Syst Rev. 2011(4):CD004919.

172. Kocher T. Eine neue reductionsmethode fur schultetrverrenkung. Berliner Klin Wehnschr. 1870;7:101-5.

173. Milch H. Treatment of dislocation of the shoulder. Surgery. 1938;3:732-40.

174. Stimson LA. An easy method of reducing dislocations of the shoulder and hip. Med Record. 1900;57:356.

175. Sahin N, Ozturk A, Ozkan Y, Atici T, Ozkaya G. A comparison of the scapular manipulation and Kocher's technique for acute anterior dislocation of the shoulder. Eklem Hastalik Cerrahisi. 2011;22(1):28-32.

176. Pantazis K, Panagopoulos A, Tatani I, Daskalopoulos B, Iliopoulos I, Tyllianakis M. Irreducible Anterior Shoulder Dislocation with Interposition of the Long Head of the Biceps and Greater Tuberosity Fracture: A Case Report and Review of the Literature. Open Orthop J. 2017;11:327-34.

177. Aronen JG, Regan K. Decreasing the incidence of recurrence of first time anterior shoulder dislocations with rehabilitation. Am J Sports Med. 1984;12(4):283-91.

178. Burkhead WZ, Jr., Rockwood CA, Jr. Treatment of instability of the shoulder with an exercise program. J Bone Joint Surg Am. 1992;74(6):890-6.

179. Ide J, Maeda S, Yamaga M, Morisawa K, Takagi K. Shoulder-strengthening exercise with an orthosis for multidirectional shoulder instability: quantitative evaluation of rotational shoulder strength before and after the exercise program. J Shoulder Elbow Surg. 2003;12(4):342-5.

180. Warby SA, Ford JJ, Hahne AJ, Watson L, Balster S, Lenssen R, Pizzari T. Effect of exercise-based management on multidirectional instability of the glenohumeral joint: a pilot randomised controlled trial protocol. BMJ Open. 2016;6(9):e013083.

181. Jakobsen BW, Johannsen HV, Suder P, Sojbjerg JO. Primary repair versus conservative treatment of first-time traumatic anterior dislocation of the shoulder: a randomized study with 10-year follow-up. Arthroscopy. 2007;23(2):118-23.

182. Rowe CR, Pierce DS, Clark JG. Voluntary dislocation of the shoulder. A preliminary report on a clinical, electromyographic, and psychiatric study of twenty-six patients. J Bone Joint Surg Am. 1973;55(3):445-60.

183. Huber H, Gerber C. Voluntary subluxation of the shoulder in children. A long-term follow-up study of 36 shoulders. J Bone Joint Surg Br. 1994;76(1):118-22.

184. Liavaag S, Stiris MG, Lindland ES, Enger M, Svenningsen S, Brox JI. Do Bankart lesions heal better in shoulders immobilized in external rotation? Acta Orthop. 2009;80(5):579-84.

185. Itoi E, Sashi R, Minagawa H, Shimizu T, Wakabayashi I, Sato K. Position of immobilization after dislocation of the glenohumeral joint. A study with use of magnetic resonance imaging. J Bone Joint Surg Am. 2001;83-A(5):661-7.

186. Smith BI, Bliven KC, Morway GR, Hurbanek JG. Management of primary anterior shoulder dislocations using immobilization. J Athl Train. 2015;50(5):550-2.

187. Paterson WH, Throckmorton TW, Koester M, Azar FM, Kuhn JE. Position and duration of immobilization after primary anterior shoulder dislocation: a systematic review and meta-analysis of the literature. J Bone Joint Surg Am. 2010;92(18):2924-33.

188. Longo UG, Loppini M, Rizzello G, Ciuffreda M, Maffulli N, Denaro V. Management of primary acute anterior shoulder dislocation: systematic review and quantitative synthesis of the literature. Arthroscopy. 2014;30(4):506-22.

189. Randelli P, Ragone V, Carminati S, Cabitza P. Risk factors for recurrence after Bankart repair a systematic review. Knee Surg Sports Traumatol Arthrosc. 2012;20(11):2129-38.

190. Johnson LL. Arthroscopy of the shoulder. Orthop Clin North Am. 1980;11(2):197-204.

191. McIntyre LF, Caspari RB. The rationale and technique for arthroscopic reconstruction of anterior shoulder instability using multiple sutures. Orthop Clin North Am. 1993;24(1):55-8.

192. Morgan CD, Bodenstab AB. Arthroscopic Bankart suture repair: technique and early results. Arthroscopy. 1987;3(2):111-22.

193. Wiley AM. Arthroscopy for shoulder instability and a technique for arthroscopic repair. Arthroscopy. 1988;4(1):25-30.

194. Warner JJ, Miller MD, Marks P. Arthroscopic Bankart repair with the Suretac device. Part II: Experimental observations. Arthroscopy. 1995;11(1):14-20.

195. Wolf EM. Arthroscopic capsulolabral repair using suture anchors. Orthop Clin North Am. 1993;24(1):59-69.

196. Snyder SJ, Strafford BB. Arthroscopic management of instability of the shoulder. Orthopedics. 1993;16(9):993-1002.

197. Levy DM, Cole BJ, Bach BR, Jr. History of surgical intervention of anterior shoulder instability. J Shoulder Elbow Surg. 2016;25(6):e139-50.

198. Milano G, Grasso A, Santagada DA, Saccomanno MF, Deriu L, Fabbriciani C. Comparison between metal and biodegradable suture anchors in the arthroscopic treatment of traumatic anterior shoulder instability: a prospective randomized study. Knee Surg Sports Traumatol Arthrosc. 2010;18(12):1785-91.

199. Warme WJ, Arciero RA, Savoie FH, 3rd, Uhorchak JM, Walton M. Nonabsorbable versus absorbable suture anchors for open Bankart repair. A prospective, randomized comparison. Am J Sports Med. 1999;27(6):742-6.

200. Hohmann E, Tetsworth K, Glatt V. Open versus arthroscopic surgical treatment for anterior shoulder dislocation: a comparative systematic review and meta-analysis over the past 20 years. J Shoulder Elbow Surg. 2017;26(10):1873-80.

201. Freedman KB, Smith AP, Romeo AA, Cole BJ, Bach BR, Jr. Open Bankart repair versus arthroscopic repair with transglenoid sutures or bioabsorbable tacks for Recurrent Anterior instability of the shoulder: a meta-analysis. Am J Sports Med. 2004;32(6):1520-7.

202. Tan CK, Guisasola I, Machani B, Kemp G, Sinopidis C, Brownson P, Frostick S. Arthroscopic stabilization of the shoulder: a prospective randomized study of absorbable versus nonabsorbable suture anchors. Arthroscopy : The Journal of Arthroscopic & Related Surgery : Official Publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2006;22(7):716-20.

203. Voos JE, Livermore RW, Feeley BT, Altchek DW, Williams RJ, Warren RF, Cordasco FA, Allen AA, Service HSSSM. Prospective evaluation of arthroscopic bankart repairs for anterior instability. Am J Sports Med. 2010;38(2):302-7.

204. Boileau P, Villalba M, Hery JY, Balg F, Ahrens P, Neyton L. Risk factors for recurrence of shoulder instability after arthroscopic Bankart repair. J Bone Joint Surg Am. 2006;88(8):1755-63.

205. Wintzell G, Haglund-Akerlind Y, Ekelund A, Sandstrom B, Hovelius L, Larsson S. Arthroscopic lavage reduced the recurrence rate following primary anterior shoulder dislocation. A randomised multicentre study with 1-year follow-up. Knee Surg Sports Traumatol Arthrosc. 1999;7(3):192-6.

206. Wintzell G, Haglund-Akerlind Y, Nowak J, Larsson S. Arthroscopic lavage compared with nonoperative treatment for traumatic primary anterior shoulder dislocation: a 2-year follow-up of a prospective randomized study. J Shoulder Elbow Surg. 1999;8(5):399-402.

207. Crall TS, Bishop JA, Guttman D, Kocher M, Bozic K, Lubowitz JH. Cost-effectiveness analysis of primary arthroscopic stabilization versus nonoperative treatment for first-time anterior glenohumeral dislocations. Arthroscopy. 2012;28(12):1755-65.

208. Hobby J, Griffin D, Dunbar M, Boileau P. Is arthroscopic surgery for stabilisation of chronic shoulder instability as effective as open surgery? A systematic review and meta-analysis of 62 studies including 3044 arthroscopic operations. Journal of Bone & Joint Surgery - British Volume. 2007;89(9):1188-96.

209. Godin J, Sekiya JK. Systematic review of arthroscopic versus open repair for recurrent anterior shoulder dislocations. Sports Health. 2011;3(4):396-404.

210. Ng C, Bialocerkowski A, Hinman R. Effectiveness of arthroscopic versus open surgical stabilisation for the management of traumatic anterior glenohumeral instability. Int J Evid Based Healthc. 2007;5(2):182-207.

211. Petrera M, Patella V, Patella S, Theodoropoulos J. A meta-analysis of open versus arthroscopic Bankart repair using suture anchors. Knee Surg Sports Traumatol Arthrosc. 2010;18(12):1742-7.

212. Chen L, Xu Z, Peng J, Xing F, Wang H, Xiang Z. Effectiveness and safety of arthroscopic versus open Bankart repair for recurrent anterior shoulder dislocation: a meta-analysis of clinical trial data. Arch Orthop Trauma Surg. 2015;135(4):529-38.

213. Pulavarti RS, Symes TH, Rangan A. Surgical interventions for anterior shoulder instability in adults. Cochrane Database Syst Rev. 2009(4):CD005077.

214. Mohtadi NG, Bitar IJ, Sasyniuk TM, Hollinshead RM, Harper WP. Arthroscopic versus open repair for traumatic anterior shoulder instability: a meta-analysis. Arthroscopy. 2005;21(6):652-8.

215. Wang L, Liu Y, Su X, Liu S. A Meta-Analysis of Arthroscopic versus Open Repair for Treatment of Bankart Lesions in the Shoulder. Med Sci Monit. 2015;21:3028-35.

216. Lenters TR, Franta AK, Wolf FM, Leopold SS, Matsen FA, 3rd. Arthroscopic compared with open repairs for recurrent anterior shoulder instability. A systematic review and meta-analysis of the literature. J Bone Joint Surg Am. 2007;89(2):244-54.

217. Monteiro GC, Ejnisman B, Andreoli CV, de Castro Pochini A, Cohen M. Absorbable versus nonabsorbable sutures for the arthroscopic treatment of anterior shoulder instability in athletes: a prospective randomized study. Arthroscopy. 2008;24(6):697-703.

218. Tan CK, Guisasola I, Machani B, Kemp G, Sinopidis C, Brownson P, Frostick S. Arthroscopic stabilization of the shoulder: a prospective randomized study of absorbable versus nonabsorbable suture anchors. Arthroscopy. 2006;22(7):716-20.

219. Griffith JF, Antonio GE, Yung PS, Wong EM, Yu AB, Ahuja AT, Chan KM. Prevalence, pattern, and spectrum of glenoid bone loss in anterior shoulder dislocation: CT analysis of 218 patients. AJR Am J Roentgenol. 2008;190(5):1247-54.

220. Rugg CM, Hettrich CM, Ortiz S, Wolf BR, Group MSI, Zhang AL. Surgical stabilization for first-time shoulder dislocators: a multicenter analysis. J Shoulder Elbow Surg. 2018;27(4):674-85.

221. Yagishita K, Thomas BJ. Use of allograft for large Hill-Sachs lesion associated with anterior glenohumeral dislocation. A case report. Injury. 2002;33(9):791-4.

222. Purchase RJ, Wolf EM, Hobgood ER, Pollock ME, Smalley CC. Hill-sachs "remplissage": an arthroscopic solution for the engaging hill-sachs lesion. Arthroscopy. 2008;24(6):723-6.

223. Di Giacomo G, De Vita A, Costantini A, de Gasperis N, Scarso P. Management of humeral head deficiencies and glenoid track. Curr Rev Musculoskelet Med. 2014;7(1):6-11.

224. Latarjet M. [Treatment of recurrent dislocation of the shoulder]. Lyon Chir. 1954;49(8):994-7.

225. Bhatia S, Frank RM, Ghodadra NS, Hsu AR, Romeo AA, Bach BR, Jr., Boileau P, Provencher MT. The outcomes and surgical techniques of the latarjet procedure. Arthroscopy. 2014;30(2):227-35.

226. Helfet AJ. Coracoid transplantation for recurring dislocation of the shoulder. J Bone Joint Surg Br. 1958;40-B(2):198-202.

227. Lafosse L, Lejeune E, Bouchard A, Kakuda C, Gobezie R, Kochhar T. The arthroscopic Latarjet procedure for the treatment of anterior shoulder instability. Arthroscopy. 2007;23(11):1242 e1-5.

228. Bonnevialle N, Thelu CE, Bouju Y, Vogels J, Agout C, Duriez P, Azoulay V. Arthroscopic Latarjet procedure with double-button fixation: short-term complications and learning curve analysis. J Shoulder Elbow Surg. 2018.

229. Castricini R, De Benedetto M, Orlando N, Rocchi M, Zini R, Pirani P. Arthroscopic Latarjet procedure: analysis of the learning curve. Musculoskelet Surg. 2013;97 Suppl 1:93-8.

230. Bessiere C, Trojani C, Carles M, Mehta SS, Boileau P. The open latarjet procedure is more reliable in terms of shoulder stability than arthroscopic bankart repair. Clin Orthop Relat Res. 2014;472(8):2345-51.

231. Hovelius L, Sandstrom B, Sundgren K, Saebo M. One hundred eighteen Bristow-Latarjet repairs for recurrent anterior dislocation of the shoulder prospectively followed for fifteen years: study I--clinical results. J Shoulder Elbow Surg. 2004;13(5):509-16.

232. Mahure SA, Mollon B, Capogna BM, Zuckerman JD, Kwon YW, Rokito AS. Risk factors for recurrent instability or revision surgery following arthroscopic Bankart repair. Bone Joint J. 2018;100-B(3):324-30.

233. Balg F, Boileau P. The instability severity index score. A simple pre-operative score to select patients for arthroscopic or open shoulder stabilisation. J Bone Joint Surg Br. 2007;89(11):1470-7.

234. Phadnis J, Arnold C, Elmorsy A, Flannery M. Utility of the Instability Severity Index Score in Predicting Failure After Arthroscopic Anterior Stabilization of the Shoulder. Am J Sports Med. 2015;43(8):1983-8.

235. Rouleau DM, Hebert-Davies J, Djahangiri A, Godbout V, Pelet S, Balg F. Validation of the instability shoulder index score in a multicenter reliability study in 114 consecutive cases. Am J Sports Med. 2013;41(2):278-82.

236. Boughebri O, Maqdes A, Moraiti C, Dib C, Leclere FM, Valenti P. Results of 45 arthroscopic Bankart procedures: Does the ISIS remain a reliable prognostic assessment after 5 years? Eur J Orthop Surg Traumatol. 2015;25(4):709-16.

237. Abouali JA, Hatzantoni K, Holtby R, Veillette C, Theodoropoulos J. Revision arthroscopic Bankart repair. Arthroscopy. 2013;29(9):1572-8.

238. Boone JL, Arciero RA. Management of failed instability surgery: how to get it right the next time. Orthop Clin North Am. 2010;41(3):367-79.

239. Blonna D, Bellato E, Caranzano F, Assom M, Rossi R, Castoldi F. Arthroscopic Bankart Repair Versus Open Bristow-Latarjet for Shoulder Instability: A Matched-Pair Multicenter Study Focused on Return to Sport. Am J Sports Med. 2016;44(12):3198-205.

240. Flinkkila T, Sirnio K. Open Latarjet procedure for failed arthroscopic Bankart repair. Orthop Traumatol Surg Res. 2015;101(1):35-8.

241. Harris JD, Gupta AK, Mall NA, Abrams GD, McCormick FM, Cole BJ, Bach BR, Jr., Romeo AA, Verma NN. Long-term outcomes after Bankart shoulder stabilization. Arthroscopy. 2013;29(5):920-33.

242. Adams JE, Sperling JW, Hoskin TL, Melton LJ, 3rd, Cofield RH. Shoulder arthroplasty in Olmsted County, Minnesota, 1976-2000: a population-based study. J Shoulder Elbow Surg. 2006;15(1):50-5.

243. Moen TC, Rudolph GH, Caswell K, Espinoza C, Burkhead WZ, Jr., Krishnan SG. Complications of shoulder arthroscopy. J Am Acad Orthop Surg. 2014;22(7):410-9.

244. Weber SC, Abrams JS, Nottage WM. Complications associated with arthroscopic shoulder surgery. Arthroscopy. 2002;18(2 Suppl 1):88-95.

245. Noud PH, Esch J. Complications of arthroscopic shoulder surgery. Sports Med Arthrosc Rev. 2013;21(2):89-96.

246. Lenters TR, Franta AK, Wolf FM, Leopold SS, Matsen FA, 3rd. Arthroscopic compared with open repairs for recurrent anterior shoulder instability. A systematic review and meta-analysis of

the literature.[see comment]. Journal of Bone & Joint Surgery - American Volume. 2007;89(2):244-54.

247. Marecek GS, Saltzman MD. Complications in shoulder arthroscopy. Orthopedics. 2010;33(7):492-7.

248. Hill JR, McKnight B, Pannell WC, Heckmann N, Sivasundaram L, Mostofi A, Omid R, Rick Hatch GF, 3rd. Risk Factors for 30-Day Readmission Following Shoulder Arthroscopy. Arthroscopy. 2017;33(1):55-61.

249. Shields E, Thirukumaran C, Thorsness R, Noyes K, Voloshin I. An analysis of adult patient risk factors and complications within 30 days after arthroscopic shoulder surgery. Arthroscopy. 2015;31(5):807-15.

250. Itoi E, Hatakeyama Y, Sato T, Kido T, Minagawa H, Yamamoto N, Wakabayashi I, Nozaka K. Immobilization in external rotation after shoulder dislocation reduces the risk of recurrence. A randomized controlled trial. J Bone Joint Surg Am. 2007;89(10):2124-31.

251. Finestone A, Milgrom C, Radeva-Petrova DR, Rath E, Barchilon V, Beyth S, Jaber S, Safran O. Bracing in external rotation for traumatic anterior dislocation of the shoulder. J Bone Joint Surg Br. 2009;91(7):918-21.

252. Griesser MJ, Harris JD, McCoy BW, Hussain WM, Jones MH, Bishop JY, Miniaci A. Complications and re-operations after Bristow-Latarjet shoulder stabilization: a systematic review. J Shoulder Elbow Surg. 2013;22(2):286-92.

253. Paulino Pereira NR, van der Linde JA, Alkaduhimi H, Longo UG, van den Bekerom MPJ. Are collision athletes at a higher risk of re-dislocation after an open Bristow-Latarjet procedure? A systematic review and meta-analysis. Shoulder Elbow. 2018;10(2):75-86.

254. Hurley ET, Lim Fat D, Farrington SK, Mullett H. Open Versus Arthroscopic Latarjet Procedure for Anterior Shoulder Instability: A Systematic Review and Meta-analysis. Am J Sports Med. 2018:363546518759540.

255. Kaar TK, Schenck RC, Jr., Wirth MA, Rockwood CA, Jr. Complications of metallic suture anchors in shoulder surgery: A report of 8 cases. Arthroscopy. 2001;17(1):31-7.

256. Rhee KJ, Kim KC, Shin HD, Kim YM. Revision using modified transglenoid reconstruction in recurred glenohumeral instability combined with anchor-induced arthropathy. Knee Surg Sports Traumatol Arthrosc. 2007;15(12):1494-8.

257. Ozbaydar M, Elhassan B, Warner JJ. The use of anchors in shoulder surgery: a shift from metallic to bioabsorbable anchors. Arthroscopy. 2007;23(10):1124-6.

258. Dhawan A, Ghodadra N, Karas V, Salata MJ, Cole BJ. Complications of bioabsorbable suture anchors in the shoulder. Am J Sports Med. 2012;40(6):1424-30.

259. Weber SC, Kauffman JI. Distant migration of a bioabsorbable implant in the shoulder. J Shoulder Elbow Surg. 2006;15(6):e48-53.

260. Athwal GS, Shridharani SM, O'Driscoll SW. Osteolysis and arthropathy of the shoulder after use of bioabsorbable knotless suture anchors. A report of four cases. J Bone Joint Surg Am. 2006;88(8):1840-5.

261. Barber FA. Biodegradable shoulder anchors have unique modes of failure. Arthroscopy. 2007;23(3):316-20.

262. Cameron KL, Mountcastle SB, Nelson BJ, DeBerardino TM, Duffey ML, Svoboda SJ, Owens BD. History of shoulder instability and subsequent injury during four years of follow-up: a survival analysis. J Bone Joint Surg Am. 2013;95(5):439-45.

263. Gartsman GM, Brinker MR, Khan M, Karahan M. Self-assessment of general health status in patients with five common shoulder conditions. J Shoulder Elbow Surg. 1998;7(3):228-37.

264. Archetti Netto N, Tamaoki MJ, Lenza M, dos Santos JB, Matsumoto MH, Faloppa F, Belloti JC. Treatment of Bankart lesions in traumatic anterior instability of the shoulder: a randomized controlled trial comparing arthroscopy and open techniques. Arthroscopy. 2012;28(7):900-8.

265. Fabbriciani C, Milano G, Demontis A, Fadda S, Ziranu F, Mulas PD. Arthroscopic versus open treatment of Bankart lesion of the shoulder: a prospective randomized study. Arthroscopy. 2004;20(5):456-62.

266. Castagna A, Borroni M, Delle Rose G, Markopoulos N, Conti M, Vinci E, Garofalo R. Effects of posterior-inferior capsular plications in range of motion in arthroscopic anterior Bankart repair: a prospective randomized clinical study. Knee Surg Sports Traumatol Arthrosc. 2009;17(2):188-94.

267. Sperber A, Hamberg P, Karlsson J, Sward L, Wredmark T. Comparison of an arthroscopic and an open procedure for posttraumatic instability of the shoulder: a prospective, randomized multicenter study. J Shoulder Elbow Surg. 2001;10(2):105-8.

268. Magnusson L, Ejerhed L, Rostgard-Christensen L, Sernert N, Eriksson R, Karlsson J, Kartus JT. A prospective, randomized, clinical and radiographic study after arthroscopic Bankart reconstruction using 2 different types of absorbable tacks. Arthroscopy. 2006;22(2):143-51.

269. Elmlund AO, Kartus J, Rostgard-Christensen L, Sernert N, Magnusson L, Ejerhed L. A 7-year prospective, randomized,

clinical, and radiographic study after arthroscopic Bankart reconstruction using 2 different types of absorbable tack. Am J Sports Med. 2009;37(10):1930-7.

270. Itoi E, Hatakeyama Y, Itoigawa Y, Omi R, Shinozaki N, Yamamoto N, Sano H. Is protecting the healing ligament beneficial after immobilization in external rotation for an initial shoulder dislocation? The American Journal of Sports Medicine. 2013;41(5):1126-32.

271. Kim SH, Ha KI, Jung MW, Lim MS, Kim YM, Park JH. Accelerated rehabilitation after arthroscopic Bankart repair for selected cases: a prospective randomized clinical study. Arthroscopy. 2003;19(7):722-31.

272. Marx RG, McCarty EC, Montemurno TD, Altchek DW, Craig EV, Warren RF. Development of arthrosis following dislocation of the shoulder: a case-control study. Journal of Shoulder & Elbow Surgery. 2002;11(1):1-5.

273. Hare KB, Vinther JH, Lohmander LS, Thorlund JB. Large regional differences in incidence of arthroscopic meniscal procedures in the public and private sector in Denmark. BMJ Open. 2015;5(2):e006659.

274. Mitchell JM. Effect of physician ownership of specialty hospitals and ambulatory surgery centers on frequency of use of outpatient orthopedic surgery. Archives of surgery (Chicago, Ill: 1960). 2010;145(8):732-8.

275. Paloneva J, Lepola V, Karppinen J, Ylinen J, Aarimaa V, Mattila VM. Declining incidence of acromioplasty in Finland. Acta orthopaedica. 2015;86(2):220-4.

276. Mattila VM, Sihvonen R, Paloneva J, Fellander-Tsai L. Changes in rates of arthroscopy due to degenerative knee disease and traumatic meniscal tears in Finland and Sweden. Acta orthopaedica. 2015:1-7.

277. Paloneva J, Lepola V, Aarimaa V, Joukainen A, Ylinen J, Mattila VM. Increasing incidence of rotator cuff repairs--A nationwide registry study in Finland. BMC musculoskeletal disorders. 2015;16:189-015-0639-6.

278. Rouse B, Chaimani A, Li T. Network meta-analysis: an introduction for clinicians. Intern Emerg Med. 2017;12(1):103-11.

279. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gotzsche PC, Ioannidis JP, Clarke M, Devereaux PJ, Kleijnen J, Moher D. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. Journal of clinical epidemiology. 2009;62(10):e1-34.

280. Furlan Ad. Pennick V. Bombardier C. van Tulder M. Editorial Board CBRG. 2009 updated method guidelines for systematic reviews in the Cochrane Back Review Group. Spine. 2009;34(18):1929-41.

281. Bourgeois FT, Murthy S, Mandl KD. Outcome reporting among drug trials registered in ClinicalTrials.gov. Ann Intern Med. 2010;153(3):158-66.

282. Lexchin J. Sponsorship bias in clinical research. Int J Risk Saf Med. 2012;24(4):233-42.

283. Stelfox HT, Chua G, O'Rourke K, Detsky AS. Conflict of interest in the debate over calcium-channel antagonists. N Engl J Med. 1998;338(2):101-6.

284. Official Statistics of Finland. Population structure [e-publication] ISSN=1797-5395. Helsinki2015.

285. Lo IK, Griffin S, Kirkley A. The development of a disease-specific quality of life measurement tool for osteoarthritis of the shoulder: The Western Ontario Osteoarthritis of the Shoulder (WOOS) index. Osteoarthritis Cartilage. 2001;9(8):771-8.

286. Samilson RL, Prieto V. Dislocation arthropathy of the shoulder. J Bone Joint Surg Am. 1983;65(4):456-60.

287. Mather RC, 3rd, Orlando LA, Henderson RA, Lawrence JT, Taylor DC. A predictive model of shoulder instability after a first-time anterior shoulder dislocation. J Shoulder Elbow Surg. 2011;20(2):259-66.

288. Rowe CR, Sakellarides HT. Factors related to recurrences of anterior dislocations of the shoulder. Clin Orthop. 1961;20:40-8.

289. te Slaa RL, Brand R, Marti RK. A prospective arthroscopic study of acute first-time anterior shoulder dislocation in the young: a five-year follow-up study. J Shoulder Elbow Surg. 2003;12(6):529-34.

290. Sachs RA, Lin D, Stone ML, Paxton E, Kuney M. Can the need for future surgery for acute traumatic anterior shoulder dislocation be predicted? J Bone Joint Surg Am. 2007;89(8):1665-74.

291. Simonet WT, Cofield RH. Prognosis in anterior shoulder dislocation. Am J Sports Med. 1984;12(1):19-24.

292. Andrade C. The numbers needed to treat and harm (NNT, NNH) statistics: what they tell us and what they do not. J Clin Psychiatry. 2015;76(3):e330-3.

293. Rücker G, Schwarzer G, Krahn U, König J. Network Meta-Analysis using Frequentist Methods. 2015.

294. Schünemann H BJ, Guyatt G, Oxman A, editors. GRADE handbook for grading quality of evidence and strength of recommendations.: GRADE Working Group; 2013. Available from: https://guidelinedevelopment.org/handbook.

295. Review Manager (RevMan). The Nordic Cochrane Centre, Copenhagen, Denmark: The Cochrane Collaboration; 2014.

296. Core Team R. R: A Language and Environment for Statistical Computing. 3.2.1 ed. Vienna, Austria: R Foundation for Statistical Computing; 1998.

297. Evidence Prime I. GRADEpro GDT: GRADEpro Guideline Development Tool [Software]. McMaster University; 2015.

298. Wintzell G, Haglund-Akerlind Y, Ekelund A, Sandstrom B, Hovelius L, Larsson S. Arthroscopic lavage reduced the recurrence rate following primary anterior shoulder dislocation. A randomised multicentre study with 1-year follow-up. Knee surgery, sports traumatology, arthroscopy : official journal of the ESSKA. 1999;7(3):192-6.

299. Robinson CM, Jenkins PJ, White TO, Ker A, Will E. Primary arthroscopic stabilization for a first-time anterior dislocation of the shoulder. A randomized, double-blind trial. Journal of Bone & Joint Surgery - American Volume. 2008;90(4):708-21.

300. Liavaag S, Brox JI, Pripp AH, Enger M, Soldal LA, Svenningsen S. Immobilization in external rotation after primary shoulder dislocation did not reduce the risk of recurrence: a randomized controlled trial. The Journal of bone and joint surgeryAmerican volume. 2011;93(10):897-904.

301. Sperber A, Hamberg P, Karlsson J, Sward L, Wredmark T. Comparison of an arthroscopic and an open procedure for posttraumatic instability of the shoulder: a prospective, randomized multicenter study. Journal of Shoulder & Elbow Surgery. 2001;10(2):105-8.

302. Franchignoni F, Vercelli S, Giordano A, Sartorio F, Bravini E, Ferriero G. Minimal clinically important difference of the disabilities of the arm, shoulder and hand outcome measure (DASH) and its shortened version (QuickDASH). J Orthop Sports Phys Ther. 2014;44(1):30-9.

303. Mohtadi NG, Chan DS, Hollinshead RM, Boorman RS, Hiemstra LA, Lo IK, Hannaford HN, Fredine J, Sasyniuk TM, Paolucci EO. A randomized clinical trial comparing open and arthroscopic stabilization for recurrent traumatic anterior shoulder instability: two-year follow-up with disease-specific quality-of-life outcomes. The Journal of bone and joint surgeryAmerican volume. 2014;96(5):353-60.

304. Kim SH, Ha KI, Jung MW, Lim MS, Kim YM, Park JH. Accelerated rehabilitation after arthroscopic Bankart repair for selected cases: a prospective randomized clinical study.

Arthroscopy : The Journal of Arthroscopic & Related Surgery : Official Publication of the Arthroscopy Association of North America and the International Arthroscopy Association. 2003;19(7):722-31.

305. Hovelius L, Olofsson A, Sandstrom B, Augustini BG, Krantz L, Fredin H, Tillander B, Skoglund U, Salomonsson B, Nowak J, Sennerby U. Nonoperative treatment of primary anterior shoulder dislocation in patients forty years of age and younger. a prospective twenty-five-year follow-up. J Bone Joint Surg Am. 2008;90(5):945-52.

306. Lahdeoja T, Karjalainen T, Jokihaara J, Salamh P, Kavaja L, Agarwal A, Winters M, Buchbinder R, Guyatt G, Vandvik PO, Ardern CL. Subacromial decompression surgery for adults with shoulder pain: a systematic review with meta-analysis. Br J Sports Med. 2019.

307. Plath JE, Saier T, Feucht MJ, Minzlaff P, Seppel G, Braun S, Hatch D, Imhoff AB. Patients' expectations of shoulder instability repair. Knee Surg Sports Traumatol Arthrosc. 2018;26(1):15-23.

308. Whelan DB, Kletke SN, Schemitsch G, Chahal J. Immobilization in External Rotation Versus Internal Rotation After Primary Anterior Shoulder Dislocation: A Meta-analysis of Randomized Controlled Trials. The American Journal of Sports Medicine. 2016;44(2):521-32.

309. Aboalata M, Plath JE, Seppel G, Juretzko J, Vogt S, Imhoff AB. Results of Arthroscopic Bankart Repair for Anterior-Inferior Shoulder Instability at 13-Year Follow-up. Am J Sports Med. 2017;45(4):782-7.

310. Castagna A, Markopoulos N, Conti M, Delle Rose G, Papadakou E, Garofalo R. Arthroscopic bankart suture-anchor repair: radiological and clinical outcome at minimum 10 years of follow-up. Am J Sports Med. 2010;38(10):2012-6.

311. Franceschi F, Papalia R, Del Buono A, Vasta S, Maffulli N, Denaro V. Glenohumeral osteoarthritis after arthroscopic Bankart repair for anterior instability. Am J Sports Med. 2011;39(8):1653-9.

312. Kartus C, Kartus J, Matis N, Forstner R, Resch H. Long-term independent evaluation after arthroscopic extra-articular Bankart repair with absorbable tacks. Surgical technique. J Bone Joint Surg Am. 2008;90 Suppl 2 Pt 2(Suppl 2 Pt 2):262-74.

313. Marquardt B, Witt KA, Gotze C, Liem D, Steinbeck J, Potzl W. Long-term results of arthroscopic Bankart repair with a bioabsorbable tack. Am J Sport Med. 2006;34(12):1906-10.

314. Flinkkila T, Knape R, Sirnio K, Ohtonen P, Leppilahti J. Long-term results of arthroscopic Bankart repair: Minimum 10 years

of follow-up. Knee Surg Sports Traumatol Arthrosc. 2018;26(1):94-9.

315. Privitera DM, Bisson LJ, Marzo JM. Minimum 10-year follow-up of arthroscopic intra-articular Bankart repair using bioabsorbable tacks. Am J Sports Med. 2012;40(1):100-7.

316. Moroder P, Odorizzi M, Pizzinini S, Demetz E, Resch H, Moroder P. Open Bankart Repair for the Treatment of Anterior Shoulder Instability without Substantial Osseous Glenoid Defects: Results After a Minimum Follow-up of Twenty Years. J Bone Joint Surg Am. 2015;97(17):1398-405.

317. Pelet S, Jolles BM, Farron A. Bankart repair for recurrent anterior glenohumeral instability: results at twenty-nine years' follow-up. Journal of shoulder and elbow surgery / American Shoulder and Elbow Surgeons [et al]. 2006;15(2):203-7.

318. Mizuno N, Denard PJ, Raiss P, Melis B, Walch G. Long-term results of the Latarjet procedure for anterior instability of the shoulder. J Shoulder Elbow Surg. 2014;23(11):1691-9.

319. Fabre T, Abi-Chahla ML, Billaud A, Geneste M, Durandeau A. Long-term results with Bankart procedure: a 26-year follow-up study of 50 cases. J Shoulder Elbow Surg. 2010;19(2):318-23.

320. Bouju Y, Gadea F, Stanovici J, Moubarak H, Favard L. Shoulder stabilization by modified Latarjet-Patte procedure: results at a minimum 10 years' follow-up, and role in the prevention of osteoarthritis. Orthop Traumatol Surg Res. 2014;100(4 Suppl):S213-8.

321. Berendes TD, Wolterbeek R, Pilot P, Verburg H, te Slaa RL. The open modified Bankart procedure - Outcome at follow-up of 10 to 15 years. J Bone Joint Surg Br. 2007;89b(8):1064-8.

322. Allain J, Goutallier D, Glorion C. Long-term results of the Latarjet procedure for the treatment of anterior instability of the shoulder. J Bone Joint Surg Am. 1998;80(6):841-52.

323. Clarke MG, Dewing CB, Schroder DT, Solomon DJ, Provencher MT. Normal shoulder outcome score values in the young, active adult. J Shoulder Elbow Surg. 2009;18(3):424-8.

324. Owens BD, DeBerardino TM, Nelson BJ, Thurman J, Cameron KL, Taylor DC, Uhorchak JM, Arciero RA. Long-term follow-up of acute arthroscopic Bankart repair for initial anterior shoulder dislocations in young athletes. Am J Sport Med. 2009;37(4):669-73.

325. Yian EH, Ramappa AJ, Arneberg O, Gerber C. The Constant score in normal shoulders. J Shoulder Elbow Surg. 2005;14(2):128-33.

326. Vrotsou K, Avila M, Machon M, Mateo-Abad M, Pardo Y, Garin O, Zaror C, Gonzalez N, Escobar A, Cuellar R. Constant-Murley

Score: systematic review and standardized evaluation in different shoulder pathologies. Qual Life Res. 2018;27(9):2217-26.

327. Rollick NC, Ono Y, Kurji HM, Nelson AA, Boorman RS, Thornton GM, Lo IK. Long-term outcomes of the Bankart and Latarjet repairs: a systematic review. Open Access J Sports Med. 2017;8:97-105.

328. Boselli KJ, Ahmad CS, Levine WN. Treatment of glenohumeral arthrosis. Am J Sports Med. 2010;38(12):2558-72.

329. Hovelius L, Vikerfors O, Olofsson A, Svensson O, Rahme H. Bristow-Latarjet and Bankart: a comparative study of shoulder stabilization in 185 shoulders during a seventeen-year follow-up. J Shoulder Elbow Surg. 2011;20(7):1095-101.

330. Birkmeyer JD, Reames BN, McCulloch P, Carr AJ, Campbell WB, Wennberg JE. Understanding of regional variation in the use of surgery. Lancet. 2013;382(9898):1121-9.

331. Koval KJ, Harrast JJ, Anglen JO, Weinstein JN. Fractures of the distal part of the radius. The evolution of practice over time. Where's the evidence? The Journal of bone and joint surgeryAmerican volume. 2008;90(9):1855-61.

332. Pike J, Leith J. Type II error in the shoulder and elbow literature. J Shoulder Elbow Surg. 2009;18(1):44-51.

333. McGauran N, Wieseler B, Kreis J, Schuler YB, Kolsch H, Kaiser T. Reporting bias in medical research - a narrative review. Trials. 2010;11:37.

334. Moseley JB, O'Malley K, Petersen NJ, Menke TJ, Brody BA, Kuykendall DH, Hollingsworth JC, Ashton CM, Wray NP. A controlled trial of arthroscopic surgery for osteoarthritis of the knee. The New England journal of medicine. 2002;347(2):81-8.

335. Sihvonen R, Paavola M, Malmivaara A, Itala A, Joukainen A, Nurmi H, Kalske J, Jarvinen TL, Finnish Degenerative Meniscal Lesion Study G. Arthroscopic partial meniscectomy versus sham surgery for a degenerative meniscal tear. The New England journal of medicine. 2013;369(26):2515-24.

336. Paavola M, Malmivaara A, Taimela S, Kanto K, Inkinen J, Kalske J, Sinisaari I, Savolainen V, Ranstam J, Jarvinen TLN, Finnish Subacromial Impingement Arthroscopy Controlled Trial I. Subacromial decompression versus diagnostic arthroscopy for shoulder impingement: randomised, placebo surgery controlled clinical trial. BMJ. 2018;362:k2860.

APPENDICES

Appendix Table 1. *Identified unpublished RCTs from the International Clinical Trials Registry Platform.*

Author, Country	Registration number	Study type	Intervention	Control	Target sample size	Primary outcome measure	Query result*	Conference abstract only	Recruitment completed	Estimated completion date
First-time traumatic shoulder dislocation										
Sandow, M. 1996 USA	Not registered	RCT	Arthroscopic Bankart repair	Immobilization for 4 weeks	39	Redislocation rate	Not published	X		
Miller, BS. 2007 UK	Not registered	RCT	Immobilization in ER	Immobilization in IR	30	Redislocation rate	Not published	X		
Kelly, CP. 2011 UK	Not registered	RCT	Immobilization in ER	Immobilization in IR	72	Compliance	No contact information available	X		
McCarty, EC. USA	NCT00707018	RCT	Immobilization in ER	Immobilization in IR	50	Recurrent instability	No contact information available		X	2012
Nicolaou, N. UK	ISRCTN41070054	RCT	Immobilization in ER	Immobilization in IR	50	Redislocation rate	Not published	X	X	2010
Pimpalnerkar, A. UK	ISRCTN48254181	RCT	Immobilization in ER	Immobilization in IR	150	Recurrence	No response		X	2008

Last update (ICTRP): 23.1.2018

ASES: American Shoulder and Elbow Shoulder Score; ER: External rotation; ICTRP: International Clinical Trials Registry Platform; IR: Internal rotation; OIS: Oxford Instability Shoulder Score; RCT: Randomized controlled trials; WOSI: Western Ontario Shoulder Instability Index. Adapted from Kavaja et al. Br J Sports Med 2018. (I)

**We attempted (and failed) to reach the authors to inquire about the possible publication of the study.*

Appendix Table 2. *Ongoing randomized controlled trials registered in the International Clinical Trials Registry Platform.*

Author, Country	Registration number	Study type	Sponsorship	Intervention	Control	Target SS	Primary OM	Recruitment status	Estimated completion date
First-time traumatic shoulder dislocation									
Bell, S Australia	ACTRN12606000196549	RCT	Industry	Open BR with bio-A sutures	Open BR with non-A sutures	236	Recurrent instability	Recruiting	NR
Johnson, A Australia	ACTRN12612000442808	RCT	Academic	Immobilization in ER	Arthroscopic BR	50	WOSI	Not yet recruiting	NR
Litchfield, R Canada	NCT01620619	RCT	Academic	Arthroscopic BR and RI closing	Arthroscopic BR	142	WOSI	Status unknown	May 2016
Pelet, S Canada	NCT01111500	RCT	Academic	Immobilization in ER	Immobilization in IR	50	Healing of labrum (MRI)	Recruiting	Feb 2015
Pougès, C France	NCT03315819	RCT	Academic	Arthroscopic BR	Immobilization in IR (Dujarrier)	40	Recurrence at 2 years	Recruiting	Mar 2018
Senthikumaran, S. United Kingdom	ISRCTN13628010	RCT	Academic	Arthroscopic BR and early mobilization	Arthroscopic BR and immobilization for 6 weeks	60 (stopped at 28)	Failure of surgery	Ready	Nov 2017
Walker, T Australia	ACTRN12611001183976	RCT	Other collaborative groups	Immobilization in ER and PT	Immobilization in ER and different PT	200	Redislocation rate	Recruiting	Feb 2019
Whelan, DB Canada	NCT02197819	RCT	Academic	Immobilization in ER	Immobilization in IR	75	Redislocation rate	Recruiting	Feb 2019

Chronic post-traumatic shoulder instability									
Caiqi, X China	ChiCTR-IOR-17010736	RCT	Academic	LHBT Transfer with BR	Conjoined tendon transfer with BR	120	Rowe-Oxford Score	Recruiting	Feb 2020
Elamo, SP Finland	NCT01998048	RCT	Academic	Arthroscopic BR	Open Latarjet	120	Recurrent instability	Recruiting	Dec 2017
Eshoj, H Denmark	NCT02371928	RCT	Academic	Neuromuscular exercise programme	Standard home exercise programme	80	WOSI	Active, but not recruiting	Jun 2019
Fenglong, L China	ChiCTR-INR-17013927	RCT	Academic	Arthroscopic Latarjet	Open Latarjet	60	Dislocation rate	Recruiting	NR
Ferreira, A Brazil	NCT02535585	RCT	Academic	Arthroscopic BR with SutureTak	Arthroscopic BR with Pushlock	54	Rowe scale	Recruiting	Apr 2019
Galal, H Egypt	PACTR201702001986912	RCT	Academic	Latarjet	Latarjet with remplissage	60	OSIS	Recruiting	Jun 2018
Lapner, P Canada	NCT02060227	RCT	Academic	Arthroscopic BR	Open Latarjet	120	WOSI	Recruiting	Dec 2018
Li, F China	NCT01912027	RCT	Academic	Arthroscopic Latarjet	Open Latarjet	30	ROM	Status unknown	May 2014
MacDonald, PB Canada	NCT01324531	RCT	Academic	Arthroscopic BR	Arthroscopic BR with remplissage	150	WOSI	Active, but not recruiting	Dec 2019
Maman, E Israel	NCT00901797	RCT	Academic	Arthroscopic BR	Arthroscopic BR and RI closing	100	Recurrent instability	Status unknown	May 2011
Moroder, P Austria	ISRCTN85886529	RCT	Academic	Open Latarjet	Open J-Bone graft	60	WOSI	Recruiting	Mar 2024
Wong, I Canada	NCT02510625	RCT	Academic	Arthroscopic BR	Arthroscopic Anatomic Glenoid Reconstruction	200	WOSI	Recruiting	Sep 2022

Last update (ICTRP): 23.1.2018
ASES: American Shoulder and Elbow Shoulder Score; Bio-A: Bioabsorbable; BR: Bankart repair; DASH: Disabilities of Arm, Shoulder and Hand; EQ: Euro quality of life; ER: External rotation; IR: Internal rotation; MRI: Magnetic resonance imaging; Non-A: Non-absorbable; NR: Not reported; OM: Outcome measure; OSIS: Oxford Shoulder Instability Index; PT: Physiotherapy; RCT: Randomized controlled trial; RI: Rotator interval; SS: Sample size; SST: Simple Shoulder Test; SSV: Subjective Shoulder Value; UCLA: University of California, Los Angeles Shoulder Score; VAS: Visual Analogue Scale; WDS: Walch Duplay Score; WOSI: Western Ontario Shoulder Instability Index. Adapted from Kavaja et al. Br J Sports Med 2018. (I)

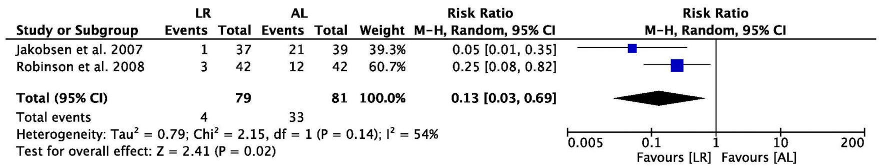
Appendix Table 3. *Assessment of risk of bias in the included RCTs.*

Author, year	1. Randomized?	2. Allocation concealed?	3. Patient blinded?	4. Care provider blinded?	5. Outcome assessor blinded?	6. Dropout rate?	7. ITT?	8. Selective reporting?	9. Equal at baseline?	10. Co-interventions?	11. Compliance?	12. Timing of assessment?	Total	IS and COI
First-time traumatic dislocation														
Early surgery														
Kirkley et al. (I) 1999[22], (II) 2005[48]	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	9	IR: (I) None, (II) NR (I, II) CI: NR
Wintzell et al. (I) 1999[298], (II) 1999[206]	Unclear	Yes	No	No	No	Yes	Yes	No	Yes	Yes	Yes	Unclear	6	(I, II) IS: NR (I, II) CI: NR
Jakobsen et al. 2007[181]	Unclear	Yes	No	No	No	Yes	Yes	Unclear	Yes	Yes	Yes	Unclear	6	IS: NR CI: None
Robinson et al. 2008[299]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	11	IS: None CI: None
Arm position														
Itoi et al. 2007[250]	Yes	Unclear	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	7	IS: Alcare CI: None
Finestone et al. 2009[251]	Unclear	Unclear	No	No	No	Yes	Yes	Unclear	Unclear	Yes	Yes	No	4	IS: None CI: None
Liavaag et al. 2011[300]	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	9	IS: None CI: None
Heidari et al. 2014[46]	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	8	IS: None CI: None
Whelan et al. 2014[52]	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	9	IS: None CI: None
Use of restriction band														
Itoi et al. 2013[270]	Yes	Unclear	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	7	IS: Alcare CI: Potential

Chronic post-traumatic shoulder instability														
Open or arthroscopic surgery														
Sperber et al. 2001[301]	Unclear	Yes	No	No	No	Yes	Yes	No	Yes	Yes	Yes	Unclear	6	IS: NR CI: NR
Fabbriciani et al. 2004[265]	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	8	IS: NR CI: NR
Netto et al. 2012[264]	Yes	Yes	No	No	No	Yes	Yes	Yes	Unclear	Yes	Yes	No	7	IS: NR CI: None
Mohtadi et al. 2014[303]	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	8	IS: None CI: None
Absorbable or non-absorbable implant materials (anchors)														
Warme et al. 1999[199]	Unclear	Yes	No	No	No	Yes	Yes	No	Unclear	Yes	Yes	No	5	IS: S&N CI: None
Tan et al. 2006[202]	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	No	9	IS: NR CI: NR
Milano et al. 2010[198]	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10	IS: NR CI: NR
Addition of posterior capsular plication														
Castagna et al. 2009[266]	Unclear	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	8	IS: NR CI: NR
Different absorbable implant materials														
(I) Magnusson et al. 2006[268] (II) Elmlund et al. 2009[269]	Unclear	Yes	No	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	7	IS: (I) None, (II) S&N CI: (I) NR, (II) Potential
Absorbable or non-absorbable suture materials														
Monteiro et al. 2008[217]	Unclear	Yes	No	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	7	IS: DePuy Mitek CI: None
Rehabilitation														
Kim et al. 2003[304]	Unclear	Yes	No	No	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	No	7	IS: NR CI: NR
Anatomic versus non-anatomic surgery														
Salomonsson et al. 2009[51]	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No	8	IS: NR CI: None

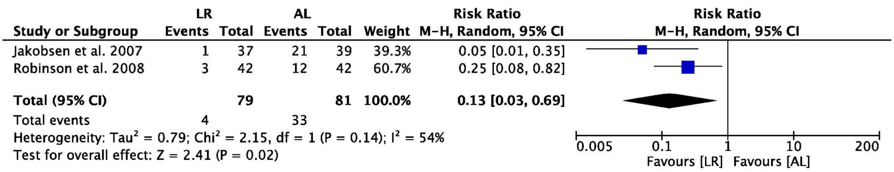
A: Absorbable; Non-A: Non-absorbable; COI: Conflict of interest; IS: Industrial sponsorship; NA: Not applicable; S&N: Smith & Nephew. Adapted from Kavaja et al. Br J Sports Med 2018.

(I)



Appendix Figure 1. Risk ratio of redislocation after a labrum repair versus arthroscopic lavage. AL: Arthroscopic lavage; CI: Confidence interval; LR: Labrum repair; M-H: Mantel-Haenszel Test. Reproduced with permission from BMJ Publishing Group Ltd. Kavaja et al. Br J Sports Med 2018. (I)

A



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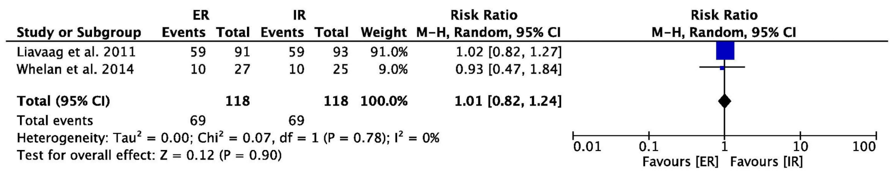

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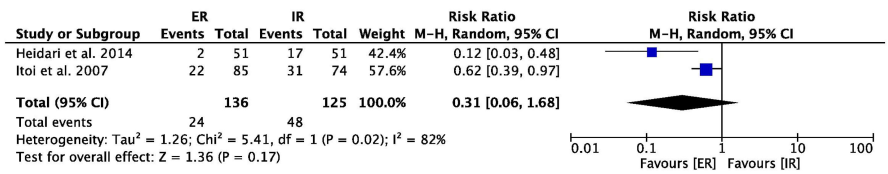
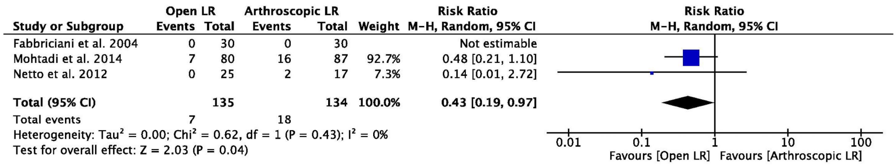


Appendix Figure 2. Risk ratio of (A) recurrent dislocation, (B) chronic post-traumatic instability after immobilization in external rotation (ER) versus internal rotation (IR) in younger patients (average age 23.4 years, range 14-40), and (C) chronic post-traumatic instability after immobilization in ER versus IR in older patients (average age 36 years, range 12-90). CI: Confidence interval; ER: External rotation; IR: Internal rotation; M-H: Mantel-Haenszel Test. Reproduced with permission from BMJ Publishing Group Ltd. Kavaja et al. Br J Sports Med 2018. (I)

A



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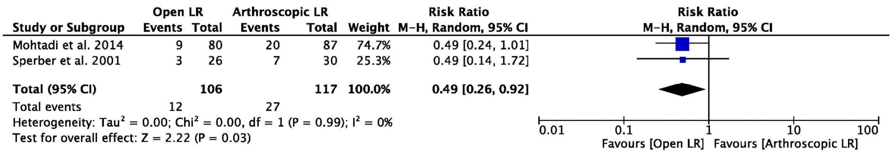
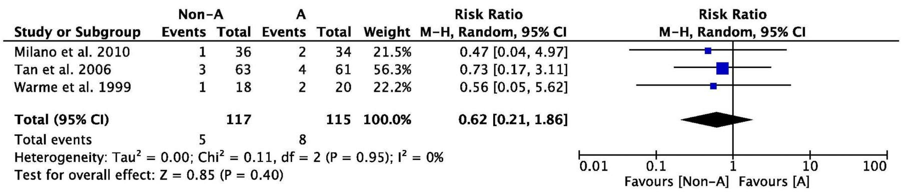


Appendix Figure 3. Risk ratio of (A) redislocation and (B) chronic post-traumatic instability after an open versus arthroscopic labrum surgery for chronic post-traumatic shoulder instability. CI: Confidence interval; LR: Labrum repair; M-H: Mantel-Haenszel Test. Reproduced with permission from BMJ Publishing Group Ltd. Kavaja et al. Br J Sports Med 2018. (I)



Appendix Figure 4. Risk ratio of redislocation after labrum surgery with non-absorbable versus absorbable suture anchors. A: Absorbable; CI: Confidence interval; M-H: Mantel-Haenszel Test; Non-A: Non-absorbable. Reproduced with permission from BMJ Publishing Group Ltd. Kavaja et al. Br J Sports Med 2018. (I)